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Aligning Performance Measurement System with Lean Manufacturing Enterprise

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Abstract
The importance of the research arises from the scientific debate recently raised about successful spreading of lean practices application across three different stages of development in lean thinking. During the last fifteen years, lean principles and practices have developed from production cell level to value stream level and finally to the modern direction towards lean enterprise perspective which requires a performance measurement system both analogical and supportive to this development.The expansion in the application of lean practices at every stage of lean development increases the degree of complexity in order to achieve synchronization through managing lean value streams within the enterprise, which require the researches to focus on how to design a performance measurement and evaluation model at lean enterprise level.This research attempts to reach a model to evaluate performance at enterprise level; a model which meets the needs of management and stakeholders in performance evaluation. This leads to improving the effectiveness and efficiency of managing the enterprise performance under the transformation to Lean Enterprise.
Keywords: lean performance Measurement System

1. Introduction

Strategic management highly needs managerial accounting information which supports it in formulation, implementation and control of strategy. The main function of managerial accounting is to serve management by having an impact on its behavior in a way that leads to a correspondence between executive businesses and enterprise strategy.
Managerial accounting, on the other hand, maintains an important role in responding to constant changes in modern environment. Such changes include technology and its impact on competitor behavior, relationships with suppliers, and consumers. It is normal then for the enterprise strategy to change from time to time to respond to these changes to fit the dynamic requirements of strategic management (Cand et al., 2009).
Most of the previous studies have focused on the use of mono -dimensional analytical approach which focuses on one dimension of multiple dimensions such as strategy, enterprise design, and enterprise theory.
These approaches enable a deep understanding of one enterprise direction and its characteristics. The outcome - as a large integrated image of the enterprise - often does not become evident through this kind of one-direction analyses. From modern managerial point of view, the enterprise would be connected as a group of subsystems that interact and integrate to form a large integrated system, such as supply net-works, manufacturing systems, human resource development, information systems, accounting, strategic planning ..... etc.
This direction provides a deeper understanding of overlapping and integrated relations across different systems within the enterprise. It also allows the perception of the value achieved and moved to stakeholders. Stakeholders have their steady expectations in a sharply competitive environment that grows bigger under the global economy, of course in addition to diversity of products and services, increase of available information, and industry improvement, where all of this leads to an unsettled atmosphere of changes inside the enterprise.
In order to control this dynamic, competitive environment, and improve the overall performance of enterprises, it is a must for enterprises to adopt initiatives to system change and control, such as 'Total Quality Management' (TQM), 'Just In Time Technique' (JIT), Six Sigma, 'Process Re-engineering', and 'Lean Manufacturing'. These initiatives are based on changing the system across the enterprise and functional borders so as to include customers and suppliers to ensure a shift from enterprise functions to enterprise business processes and activities. However, it should be considered that each initiative of these initiatives has a working technique that must be implemented accurately, as that's where the incorrect and improper use of change initiatives, one reason for which might be the misunderstanding and lack of interdependence on processes and systems, or by focusing on one of the benefits of stakeholders, leads to problem that always appears in a lot of enterprises, i.e. a problem partial maximization of targets without focusing on overall maximization of enterprise goals as a large system that consists of these sub-systems.
Developing performance at enterprise level requires a radical re-think of how to manage the enterprise through its adoption to one system change and control initiative. Womack, James and Daniel have suggested in 1990 the use and implementation of the lean principles and practices to improve enterprise overall performance (Womack et al., 1991).

2. Lean as a Managerial System

The main idea behind the adoption and execution of lean principles and practices arises from maximizing value for customers, as well as eliminating or reducing waste to zero waste. Lean simply means creating multiple values to customers in the context of limited resources, and trying to fully use them in accordance with a specific and accurate mechanism that helps reduce waste to its lowest level (Womack et al., 1991).

Lean principles and practices have - during the last fifteen years – developed from 'Production Cell Level' to 'Value Stream Level', and finally to 'The lean Enterprise Perspective' (Womack et al., 2005).

To do this, it requires a massive shift towards the adoption of special lean-related principles and practices. This shift in turn requires the elimination of functional borders, the redesign of processes which are integrated across enterprises, and the authorization and encouragement of personnel to ensure the participation of all stakeholders in the 'Value Stream'.

It is known that enterprises operating under Lean Thinking attach great importance to the values they provide to their customers and focus on this dimension. They always work on it to increase that value reaching the ultimate goal of providing customer with a full value through integrated processes that reduce waste value to zero level.

Hence, to achieve this goal, managerial thought followed with the enterprise must be changed from focusing on marginal maximization of technology, assets, and various units, to focusing on the flow of products and services through 'Value Stream'. Value Stream runs horizontally through the technology available at the enterprise, the assets, and the various customer units.

The waste reduction through value stream can be reached by adopting managerial policies leading to lesser human effort, smaller workplace, lesser capital, lesser production time, and accordingly lesser overall cost, minimized errors compared to traditional work systems. This is in addition to the response to all the consumer desires with a greater diversity in products according to their needs, with high quality, lower cost, and faster time to meet their needs, in addition to the fact that data management shall become simpler and more accurate (Womack et al., 1996).

The goal of enterprise lean management is transforming value to all parties with a special interest in this enterprise by adopting the lean model at enterprise level so that frequent improvements should be included in the strategic plan. Controlling the transformation cycle to lean enterprise of includes frequent improvements in strategic plan. These improvements are implemented through the study and evaluation of internal and external environment of the enterprise, and this consequently leads us to make continuous adjustments to policies, practices, and managerial systems (Murman et al., 2002).

Moreover, these studies and evaluations of the internal and external environment requires effectuation of the role of feedback on an ongoing basis between long and short term transformation cycles so that a linkage between the strategic goals and performance metrics used to measure and evaluate such goals could be achieved. There is an overlap and consistency among the strategic goals that should work in the same direction; such goals which are typically measured and evaluated by many directions. Some of which include metrics to evaluate the performance of various requirements and desires of stakeholders. Some include metrics to evaluate the performance of the enterprise external environment, and some include metrics to evaluate the performance of the enterprise as a whole (Murman et al., 2002).

There are many elements that could affect transformation in policies, practices, and managerial systems necessary as part of the transformation process to lean enterprise. Of these elements is the existence of a communication between the elements of the strategic plan across the enterprise as a whole, leadership, resource allocation, and creating an environment that adopts the lean thought. It is necessary that there be a strategic plan characterized by an effective and successful engagement and communication element, which requires associating goal performance metrics with short and long term activities. Adapting available resources, leadership impact, and the impact of lean thought adoption affects the level of performance of the enterprise as a whole. The last requires proper understanding of causal relationships between efforts to lean transformation and activities contained in the enterprise, as well as the corresponding performance metrics (Murman et al., 2002).

Accordingly, the researcher has examined some previous studies in managerial accounting in the field of 'Lean Accounting'. He found that most of them dealt with the importance of applying the principles and practices of lean manufacturing for the success of enterprises in light of the challenges of current competition. Other papers have considered the necessity for the enterprises to transform as a whole to lean enterprise in order to achieve success, and how they can achieve that. This means that most of the studies have focused on lean principles and practices, and the extent of their importance and necessity, and accounting systems corresponding to them and how to apply them. Such systems could be adapted to these practices without prejudice to performance measurement and evaluation systems for enterprises that adopt lean manufacturing thinking, which later transformed to lean enterprises. The researcher, therefore, has it crucial to discuss how suitable the current performance evaluation systems are in meeting the requirements of management and stakeholders in performance evaluation under the transformation to Lean Enterprise. The research tries to put a theoretical framework for evaluating the performance of enterprises that adopt a lean thinking fitting to its nature so as to

meet their needs and which lead to enhanced effectiveness and efficiency enterprise performance.

3. Towards a Theoretical Framework Proposed to Design of a Performance Measurement System at the Level of Projects Adopting Lean Thought

This part of the research discusses the introduction of the proposed conceptual framework which governs the development of a performance management system at the level of projects adopting lean thinking. This chapters does not aim in any case at claiming that the proposed framework serves as an antidote to all the problems that affect the performance measurement, but it rather aims at suggesting a framework for the concepts and some of the approaches to develop a performance measurement system that involves main characteristics to be decided to transform and manage the lean process at projects.

3.1 The General Framework of the Proposed Approach

Performance measurement previous studies have agreed that balanced performance scorecard approach with the four major perspectives of the card - as a minimum - presents an integrated framework for performance measurement and evaluation, as this approach is characterized by the balance of public and private, financial and non-financial metrics. It also helps associate performance with strategy, in addition to improving strategy as a continuous improvement of performance and goal achievement (Adel, 2007).

These studies have indicated in total the necessity of taking into account the following (Adel, 2007):

1. The clarity of strategy, reporting it to all facility personnel, and ensuring their understanding of it, with a mechanism for communication between all managerial levels within the facility as a way of delivering instructions, procedures, application problems, means to solve them, and so on.
2. Associating performance with metrics through a cause-effect relationship.
3. Effective, appropriate, and adequate training for workers on the importance of this approach and how to implement it.
4. The participation of subunit officials in the design of the card and its preparation to enable the measurement and evaluation of their units' performance. This has a positive impact on them concerning the empowerment, sense of responsibility, performance improvement, and elevation of self-censorship spirit.

3.1.1 Integrative Role of the Balanced Scorecard with Lean Production Approach and Proposed Integrated Technique Application

From the previous discussion, it is clear to the researcher that this is an agreement between the basic requirements for the application of lean-based production approach and the balanced performance scorecard approach as a system that supports performance evaluation in addition to the goal agreement and upgrading efficiency and quality, with the first being in implementation, the latter emphasize performance evaluation.

The researcher finds this an emphasis to the necessity of creating integration between lean-based production approach and balanced performance scorecard approach. Integration indicators and agreement aspects between card components and what lean approach is based upon can be examined before discussing the output of the integration and the application methodology of the proposed integrated approach. Agreement aspects between card components and what lean approach is based upon could be brought into discussion after outlining the goal of each approach so that basis for their integration could clearly visualize.

• Lean production represents a long-term strategy that aims at enhancing process performance and products quality and reducing diversions – in promotion of all performance aspects in general - by focusing on business processes in light of facility strategy and its goal to satisfy customers. This is done through accurate completion of business processes and exclusion any waste and what does not add value to the product so as to maintain resources, improve the efficiency of performance, and minimize defects to improve product quality. This is what achieves customer loyalty and is reflected at double impact on facility profitability: Cost reduction and sales increase with continued development and improvement reaching zero defects.

• The balanced performance scorecard approach is an effective tool for communication, measurement, and evaluation of balanced and integrated performance through the use of multiple metrics - derived from the strategy itself - for each of the card perspectives. Card perspectives are also linked to the strategy to ensure the achievement of the goals of the latter periodically and in all sub-units concerned. If the financial metrics often show short-term results, those non-financial metrics often characterized by objectivity serve the long-term, with their impact reflected on the short term and output of financial metrics. They also help raise alert when any performance restrictions from inside or outside the facility appear meanwhile shedding light on studying such restrictions and doing what is necessary to deal with them. Moreover, the evaluation phase included in the application methodology of the proposed integrated approach - as it will be seen later - helps show the extent of implementation and continuation of improvement project and their corresponding with the set strategies and within all the sub-units concerned with improvement processes.

(Malina & Selto, 2001) state that the card importance is highly seen at the delivery of strategy and controlling its implementation, ensuring goal achievement, and the correspondence between actual and planned performances.

3.1.2 Agreement aspects between the constituents of the balanced performance scorecard and what lean-based production approach can be shown as follows:

1. Customers represent the perspective of interest to the lean approach and they are the basis for developing an improvement strategy for performance efficiency and product quality. Customer perspective is a main perspective in the card.

2. Through the approach of lean production, the personnel are well attended to be trained and motivated. Delivery of strategy is also done through this approach as they form the striking force supposed to achieve the goals of strategy implementation. The balanced performance scorecard includes the perspective of learning and growth - the fourth perspective in the card – which is associated with personnel, and motivation for the rest of the perspectives. Through this perspective, the lowest waste can be reached by raising the efficiency of personnel. This perspective is also associated with the financial perspective in terms of impact.

3. The basis for lean production approach is improving the performance of business processes and excluding the waste of every aspect and kind in these business processes through accounting approaches and other supporting. The third main perspective in the balanced performance scorecard is the perspective of internal business processes.

4. Lean-based production approach aims at excluding waste to reduce the input with the production of products that outweigh the desires of customers and that are virtually defect-free. This increases the market share, and accordingly the output. This leads to a double impact on increasing the profits for the enterprise and value for the stakeholders. The first perspective of the balanced performance scorecard is the financial perspective which reflects the results of improvement and it is in this perspective that the return for the improvement of the remaining perspectives pours into.

3.2 The Proposed Structure

The researcher suggests that the proposed design for a performance measurement system at the level of projects which adopt the lean thought in addition to its use of the balanced performance scorecard as a cornerstone in the beginning should be based on a simple structure that consists of three levels of performance measurement indicators, as shown in Figure (1).

As mentioned previously, there are three levels of measurement indicators: Individual Metrics, Metric Set, and Metric Cluster (Johnston, 2002), (Lohman, 2004), (Melnyk, 2004). What links these three types of metrics are causal links. The development and improvement of this structure includes selection of measurement indicators to measure stakeholder value, establish causal relationships between measurement indicators and verify them, and manage of a consistent set of measurements in order to avoid local improvement. The procedural aspect of this design includes the use of different tools and approaches to develop and improve the structure so as to finally ensure the development of the performance measurement system in itself. In the first place comes the analysis of the stakeholder value to select performance measurement indicators. Here arise the causal relationships between measurement indicators, and then they are verified and developed using system dynamics and structural equation model. However, a dictionary should be used to define the measurement indicators to come up with consistent measurement indicators at the enterprise level.

Individual Metrics: Measurement indicators that are concerned with the tasks and activity or the performance level of an employee who contributes to the overall performance of a process or a number of processes. Those measurements have been designed to align the goals of one process or a number of processes.

Metric Sets: Measurement indicators that are interested in performing a set of activities or the whole process. The process performance is evaluated by measuring the end performance or by collecting the results of individual metrics. Each group of these groups directs, guides, organizes the activities of the individual in support of strategic goals.

Metric Clusters: They combine individual metrics and metric sets in a way that links strategic goals and stakeholder values. This ensures measurement of the overall performance of one or more of the value streams.

This structure can be represented by the value stream, as shown in Figure (1). Metric Clusters are the value flow stream or measurement indicators at the enterprise level based on the enterprise borders. Metric sets are metrics that measure performance in processes or sub-processes that the value flow stream. These sets standards play a key role in the synchronization of strategic activities and goals as well as in coordinating processes across the value flow stream. The individual metrics are the measurement indicators the building block level of the process and value stream. For example, as shown in figure (2), the individual metrics are the employee training and the number of parts produced per minute, which in turn affect the process cost or the process output, and which appear through metric sets. Therefore, the process output and its cost lead in end to the process overall cost, which refers to metric clusters (Johnston, 2002), (Lohman, 2004), (Melnyk, 2004).

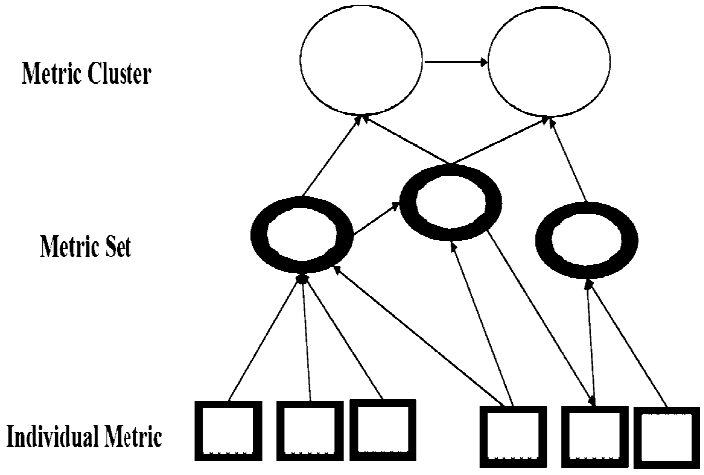

Figure (1): The Conceptual Design of the Lean Performance Measurement System in Projects

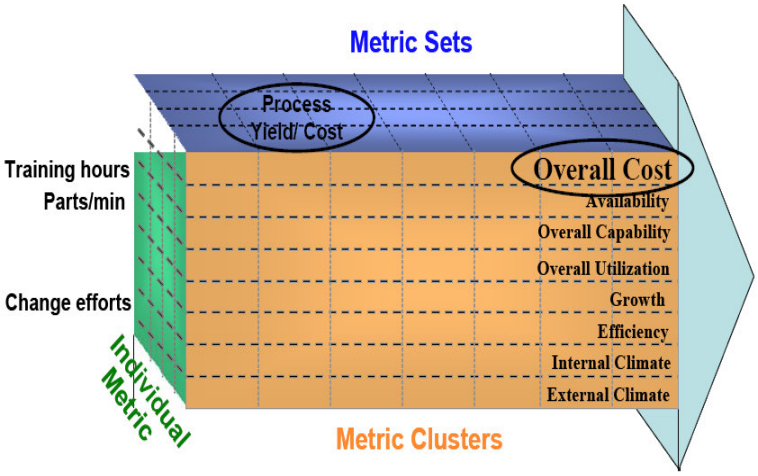

Figure (2): Representing Value Flow Stream for Performance Measurement System

3.3 Determination of Stakeholder Values and Developing Metrics Clusters and Their Weights

The aim aspired by lean process in lean-based projects is delivering value to stakeholders, taking into account value delivery strategies and the processes of the applying those strategies, and so the procedures and behavior at every level of the project levels, which must be consistent with delivering value to stakeholders. Accordingly, higher level measurement indicators represented in metric clusters of lean process in projects must be derived from the stakeholder value to be consistent with the procedures taken at the level of the enterprise as a whole.

The stakeholder theory is based on the fact that stakeholders are persons or groups that have a legitimate interest in the procedural and/or aspects of the enterprise or project activity (Freeman, 1984). Stakeholders are the owners of interests in the enterprise or project as suppliers or stakeholder for example (Earl and Clift, 1999). This means that stakeholders are groups that provide or contribute to adding a value to the enterprise with what ensures the achievement of its mission. Stakeholders are affected by consequences of any decisions and can also affect directly or indirectly the decisions made and their consequences. Both (Mcvea and Freeman, 2001) asserts that stakeholder management is an endless task to achieve balance and integration between relationships and multiple goal. Yet, many researchers such as (Smith, 2003; Sundaram and Inkpen, 2004) argue that the theory of stakeholders does not provide any form to segregate between the divergent interests of the stakeholders. (Jensen, 2002) suggests that any theory of decision-making within the enterprise should guide decision-makers to how to choose from among the stakeholders the ones who have competing even, sometimes, conflicting interests. Customers want low prices, high quality, and outstanding service. The employees want lucrative salaries, high-

quality working conditions, and certain benefits including holidays, health care, and pensions. Financiers and suppliers want less risks and more returns, whereas communities want more of charitable contributions and that companies spend more expenses on social services that benefit society as a whole, and more of local investments and employment stability. So is the case with any other stakeholders. Therefore, the leading measurement indicators represented in metric clusters and derived from stakeholder values lead to a long list of measurement indicators. And so managers may have to work a trade-off when determining metric clusters at the enterprise level to reach the balance which leads to a double value compared to available resources and capabilities.

In this context, the stakeholder value analysis approach has been addressed in the researches of (Earl and Clift, 1999) as being used to create metric clusters and customize relative weight for each cluster to facilitate the trade-off. In this manner, the stakeholder value analysis approach is divided into several steps. The first step is about identifying and defining stakeholders. This must include the internal stakeholders such as employees and management personnel as well as external stakeholders. So the stakeholder list may include about 15 to 20 entities depending on the size and borders of the enterprise. Stakeholders must be selected with the utmost precision because the stakeholder value analysis depends entirely on this process of selection and identification.

The second step is to determine the values or performance characteristics of importance to each stakeholder. This methodology includes the use of a general questionnaire that includes questions such as: "What is it that you feel it is of value to you?", "What do you expect to get from your participation in this enterprise?", "What would make the enterprise of value to you?", and "What are the measurement indicators that you will use to determine that value?". This questionnaire can be generalized by conducting interviews with one or more representatives of stakeholder groups.

In the third step, the value list provided by each stakeholder can be gathered in metric clusters as shown in a sample analysis carried out by an auto parts factory. Multiple values can be listed under one group because each of these values can be integrated with each other or similar to each other. For example, the value of "Customers appreciate better prices" can be integrated with the value of "Employee salaries". Those two values can be grouped in a single cluster under "System Cost".

The fourth step means to conduct a value trade-off. This involves appointment of the suitable weights for all values so as for the most important values receive the higher weights where the least important values receive the lower weights. Stakeholders may appoint different weights for values, but weight appointment process for each value is tiresome and cumbersome for stakeholders. Moreover, adjusting those weights may distort the analysis to a large extent. For example, a stakeholder may appoint a percentage of 90% for one of the values while appointed another appoint only 10% for the same value. The try to adjust a rate for these two weights and get their will result in a percentage of 50%. This percentage, however, does not accurately reflect the importance of this value of to any of the two aforementioned stakeholders.

So (Earl and Clift, 1999) support the use of dual comparison approach (special vector) which developed by (Saaty, 1980) wherein the main advantage of dual comparison double emerges in its enabling managers to systematically determine the weights of each value. Through the application of this approach, stakeholders shall be required to compare pairs of values at a time. This can be simplified and explained as follows:

So let's say there are five values for stakeholders a - b - c - d – e. Here each stakeholder is asked to compare between these values based on the trade-off metric in table (1), which means that any stakeholder has to determine the importance of:

A vs. B, A vs. C, A vs. D, A vs. e
B vs. C, B vs. D, B vs. E
C vs. D, C vs. E
D vs. E

Thus, assuming there are common values (n) of the stakeholders, and all stakeholders were asked to reach a number of human decisions that can expressed by the relationship {n(n-1)/2} of decisions (Activities Implemented Jointly), where these decisions can be used to build a matrix of (n) decisions, which can show a relative rough weight for each value of the overall stakeholder values.

(Earl and Clift, 1999) also added that the best way to understand the dual comparison approach is to imagine that this approach is "the average of all the possible ways of thinking" when "the ways of thinking" are the dual comparison provided by stakeholders.

Comparison Values	Definition
1	has the same degree of importance or preference
3	more important or favorable narrowly
5	more important or favorable strongly
7	more important or favorable very strongly
9	more important or favorable to the fullest extent
8,6,4,2	average values reflecting adjustment

Table (1): Preference Metric upon Which Earl and Clift Is Based

3.4 Establishing and Verifying Causal Relationships

Both (Eccles and Pyburn, 1992) see that in order to achieve success for spreading the Total Quality Management initiative, managers, for example, should bear a develop a comprehensive model for performance measurement through which a causal relationship arises from which provided that it be verified. (Ittner et al., 2003-A) have carried out a comprehensive survey on financial services industry. They found that companies which manage performance using causal models that associate financial measurement indicators with the non-financial run well. In the case of lean-based projects, they found the transformation to lean and its management involve spreading a set of practices and adopting these practices resulting in making processes more integrated and mature to the degree necessary to manage lean-based project (Hallam, 2003). To provide value for stakeholders in the best way, it is necessary to understand not only the interdependence between processes and their level of maturity but also the negative impact relationships between performance practices processes. For example, we find that the provision of training for employees would promote the process empowerment, which in turn will improve the performance process cycle. In addition to that, to ensure an effective and efficient provision of services to the customer, it is necessary to understand how and to what extent training efforts affect the overall cost of the process, which contributes to delivering a value to the customer. So, to ensure delivering the value to the specified stakeholder (who represents the customer in this case) effectively and efficiently, it is necessary to establish a causal relationship between performance measurement indicators and their verification.

Therefore, in the context of conceptual design of the proposed system, the researcher suggests, when developing a performance measurement system, to use two techniques to establish relationships between measurement indicators and their verification. These two techniques are the system dynamics and the structural equation model due to the possibility of a rapid development in designing measurement system of the lean-based project, which makes it very complicated as a result of the vast numbers of performance measurement indicators at each level in addition to the fact that lean process are mainly dependent on scientific methods (Spear, 1999). Accordingly, the system dynamics and the structural equation model represent a scientific obstacle to performance measurement and management process. And so, they both should be regulated in a way that helps overcome these obstacles through the proposed conceptual design.

In most cases, system dynamics models are developed and used to deliver, analyze, and explain the dynamics of a complicated system, where system dynamics or behavior can be defined by the use of its structure and interactions of its components. The use of quantitative and qualitative features of the system dynamics model helps understand the change in the behavior of a system components as a result of policy change or re-formation of other parts of the system. In addition, the system dynamics model provides an understanding of the change in the behavior of the various components of the system as a result of the interactions of a clear definition. But this model does not provide a clear evaluation of these interactions and the alternative stream of procedures for decision-makers (Santos, 2002). To avoid this gap, the proposed conceptual design will incorporate the structural equation model technology and the system dynamics.

As defined by (Schumacker and Lomax, 1996), the structural equation model allows the survey of a set of relationships between one or more independent variables, whether connected or separate, as well as between one or more dependent variables, whether connected or separate. The structural equation model is the combination of several analyzes, so its role is limited to test the process and not to develop a technology. In other words, the structural equation model can be used to test the verification of the cause and hypothesis of the impact relationship. But these relationships must be established first based on a theory, a knowledge, and even a certainty. Before testing the relationship itself, its direction must be understood. Therefore, incorporating system dynamics and structural equation model will provide a comprehensive tool to design a structure for performance measurement system.

The first step towards the establishment of a causal relationship is to develop a model of system dynamics that would embody the causal common relationships. Let's look at the simplified annular diagram in the figure (3) as it explains the different features that affect the system performance within the enterprise. We will find it embodies interactions and directions between different features that affect the performance and capacity of the system in doing it role. It represents also the dynamics between different activities and results. For example, we find that the loop No (3) embodies the strong dynamics between system performance and the level of employee performance. This means that the increase in the employee performance results from providing him with black belt training and this in turn results in reducing employee turnover rate. So, improving employee performance will naturally lead to improving the system performance, which will have a positive impact on the delivery time, and accordingly improving the level of customer satisfaction. Improving customer satisfaction will finally increase the net operating profits and improve the investment performance of, and thus provide an opportunity to increase the budget allocated to receive black belt training. Similarly, the loop number (1) and the loop No (2) represent the impact of supplier relationships and process capabilities on the level of system performance. This means that the system dynamics model enables the understanding of direct and indirect hypothetical measurements that would affect the system performance level. It also helps decide the time delay between the

impact of one of the performance outputs and another, such as the impact of an employee capability to improve the process. It is very important to understand the delays, but they are difficult to understand in the context of a performance measurement system (Schumacker and Lomax, 1996).

Establishing causal relationships between performance measurement indicators and understanding their behavior based on these interactions is necessary although it is not sufficient for decision-makers. Decision-makers have to verify the validity of these relationships, and to be understood the precise impact of each output of the performance on the correlated cases of performance to reach to a better understanding and a clearer explanation of the causal relationships and the variation in performance due to interactions where the structural equation model is used for this purpose.

The structural equation model addresses specifying all the potential variables and those subject to measurement. The variable subject to measurement is defined as the variable which can be noticed directly in addition to its capability to be measured. In the previous example, we find that the process cycle time is a variable that can be measured. It is also known that variables that were subject to measurement are the variables monitored or the clear indicators or variables. The potential variable is the variable that cannot be monitored directly. It is derived only from the variable subject to measurement. In the previous example also, we find that process performance is the potential variable as the variation between one, two, or more variables of those subject to measurement leads to the emergence of potential variables. Potential variables are also referred to as factors (i.e., factor analysis); they are unspecified variables. So, the structural equation model is a combination of multiple regression analysis of factor analysis. The structural equation model is divided into two parts: Measurement model and structural model. Measurement model is concerned with dealing with the relationships between variables subject to measurement and potential variables, whereas structural model is concerned with the relationships between potential variables only. One characteristic of structural equation model is that potential variables are free of random errors. This is because the errors have been estimated and removed while retaining variables that carry common differences in general.

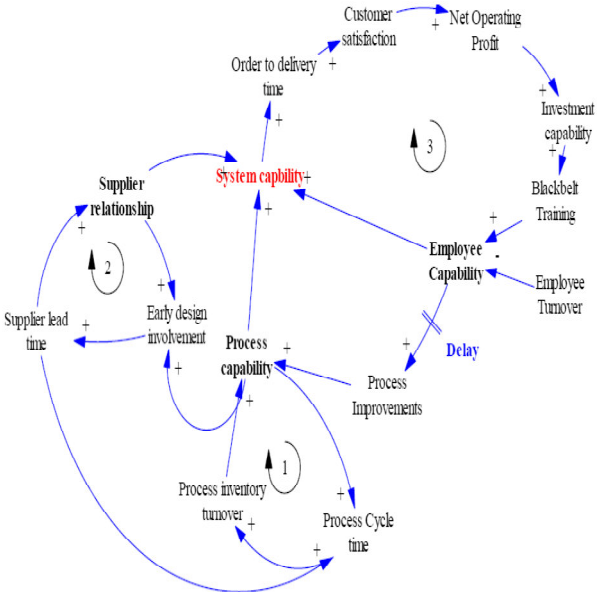

Figure (3): Example of a Causal Loop Diagram of System Performance Measurement

Figure (4) shows the structural equation model of the above example. In the structural equation model, measurements subject to measurement are represented by squares and rectangles, where potential variables are represented by circles provided that errors should be included (disturbances of potential variables) in the structural equation model diagram. The variable subject to measurement is represented by the letter (e), the potential variable by (d). Errors in the remaining differences are represented among the unspecified variables in the assumed aisles in the model (Schumacker and Lomax, 1996).

Metrics in the structural equation model appear through the variations and the regression and variation coefficients between variables. The variation can be represented by a two-headed arrow whose two heads refer to the variable itself, or in an easier way by appointing a number inside the box or circle with the variable inside.

Regression coefficients are represented by shares single-headed arrows where the head indicated to the default stream between these two variables (these are the weights applied to variables in linear regression equations). The variation between two variables is represented by two-headed curved arrow without specifying any direction.

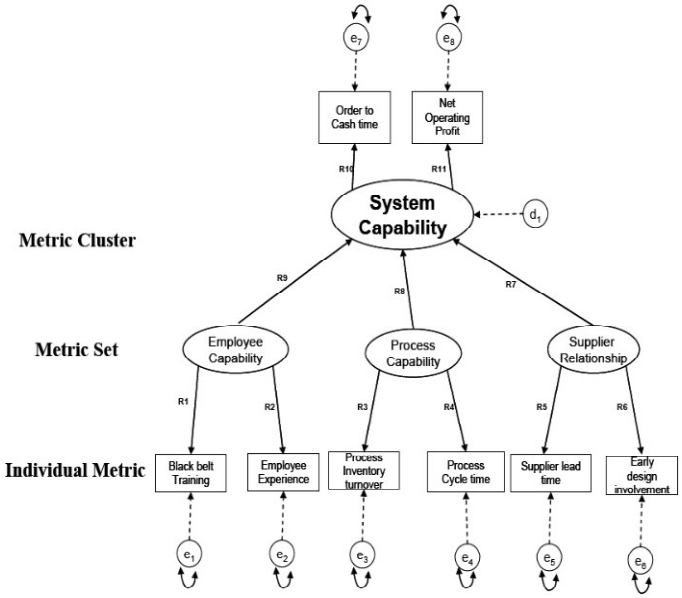

Figure (4): Structural Equation Model of System Capability Performance Measurement

Here the capability of explaining results of the structural equation model should be noted from two perspectives: Measurement model and the model as a whole, as the part of measurement model is correlated with every potential variable and its associated variables subject to measurement. Here there are three questions:
(1) How will the variables subject to measurement reflect the potential variables?
(2) Are there some variables that have been specified as better than other variables?
(3) To what extent each variable of the all the variables subject to measurement can be relied upon?
Each potential variable is to a mini-analysis of the factors, so it is possible to remove variables that look like they do not do anything except adding variation to errors. Once we extract a set of variables subject to measurement, we can draw our attention to the model as a whole to see if it fits with the data well or not, and whether there are potential variables that do not have a clear streams with other variables, or worse whether they have clear streams with the wrong signs or not.

3.5 Developing a Standardized and Consistent Set of Measurement Indicators

The purpose of understanding the stakeholder values and establishing causal relationships between measurement indicators is to avoid decisions that result in objective improvements or behavior that is not in line with the lean policy. As noted above, decision-makers in the various levels of the enterprise or in various processes may use measurement indicators themselves to achieve various performance targets. For example, process decision-maker will use inventory to ensure on-time delivery and fulfillment of customer requirements while managing the production process as a whole. Meanwhile financial decision-maker uses the measure to increase the cash-to-cash cycle. If the above-mentioned managers used different versions of the same procedure, it would lead to making suboptimal decisions, which would make such performance not in line with lean policy. Due to the enterprise complexity, it is possible to use correlated processes to the same procedure with different design factors different as described in detail in chapter III to avoid the unoptimal behavior. In this context, (Lohman, 2004) suggested to a write a dictionary of performance measurement indicators. This dictionary will include the detailed design of each element of measurement indicators for each individual measurement at the level enterprise and the owners of measurement indicators (those who develop them) and some other executive managers shall not be entitled to change elements of measurement indicators. Moreover, all the decision-makers will have to use modular design stipulated in the performance measurement indicator dictionary with what ensures the consistency and standardization of measurement indicators at the enterprise level.
One of the biggest challenges during the implementation is the need to achieve timely data verification (Martin, 2012) and for the data to be accurate at the appropriate level of details, given that access to these data requires strong support from the information technology unit (IT). To achieve this end, we recommend that the involvement of IT staff and data analysts in the implementation team.

Conclusion

This research shows that designing a performance management system is indispensable to support the transformation to the lean-based approach and its management because of the special features followed by the lean-based management. The development of the lean-based performance practices have been discussed through three stages and features. Accordingly, it was necessary to search for performance measurement system corresponding to them. This research has specified three key features to design a performance measurement system to the organizations adopting the lean approach. These three are:

• Measurement indicators of stakeholder values at the enterprise level
• Causal relationships between measurement indicators at different enterprise levels
• Standardized and consistent set of measurement indicators at the enterprise level

In light of the previous research, the researcher finds the need to separate performance measurement of lean practices in projects and traditional activities practices which represent an obstacle to the adoption of the lean practices. Through theoretical research of the common performance measurement concept and performance measurement frameworks, I have revealed that all current performance measurement do not deal with the features of lean performance measurement system in projects adopting lean thought. So, a theoretical model for the design of a performance measurement system was proposed. It shows the techniques and ways that are used and compatible with these features, and therefore the following results can be drawn from this research:

1 - For the successful transformation to lean in projects and what follows of lean-based management, it is necessary to develop a performance measurement system that meets the needs of management and stakeholders.

2 - Designing a performance measurement system must face the increase in the size and complexity of the lean practices in projects.

3 - Efforts of performance measurement that are supportive of lean initiatives must be an integral part of the enterprise performance measurement system.

4 - Causal relationships must be established between performance measurement indicators, validated, and developed on a permanent basis, taking into account the directionality of causal relationship with what enables its identification. It is validated through the use of system dynamics model techniques. In addition, the importance of causal relationship and performance variation as a result of other correlated indicators can be identified and verified using the structural equation model.

5 - The development of a standardized set of measurement indicators at the enterprise level is essential to avoid local improvement and behavior that is not in line with lean methodology. To achieve that, a measurement dictionary is written, that contains a full description of each measurement elements while identifying only a limited number of individuals that should be entitled to make amendments to any of the definitions contained in the dictionary. These individuals are the ones involved in the development of performance metrics, as well as senior executives.

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