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Evolution of Scientific Management Towards Performance Measurement and Managing Systems for Sustainable Performance in Industrial Assets: Philosophical Point of View

R.M. Chandima Ratnayake (1)

Abstract

Even though remarkable progress has been made over recent years in the design of performance measurement frameworks and systems, many companies are still primarily relying on traditional financial performance measures. This paper presents an overview of modern descendents and historical antecedents of performance measurement and attempts to give philosophical definition, in fact addressed the evolution of traditional ways of measuring performance. The paper suggests that modern frameworks have indeed addressed the organizations external to them while satisfying the conditions internal to them and providing an analogy of the notion of kuhn's scientific paradigm. This analogy is consistent with the fundamental proposition of Kuhnian philosophy of science, that progress only happens thorough successive and abrupt shifts of paradigm.

Keywords: Performance measurement, management, Kuhn's philosophy.

(1) Assistant Professor (IKM)/ Doctoral Research Fellow (CIAM). E-mail: chandima.ratnayake@uis.no
Center for Industrial Asset Management (CIAM), Faculty of Science & Technology. University of Stavanger - UiS. N- 4036, STAVANGER. NORWAY.

Introduction

The starting point for organized, self conscious activity was started with the synthesis and extension of systematic management, introduced by Frederick W. Taylor (1856-1915), late nineteenth century effort to bring order and system to manufacturing or merely improving organization productivity. But the scientific management did not begin or end with Taylor. Hence the purpose of this article is to describe the paradigm shift that prepared the way for evolution of modern performance measurement and managing research (Daniel 1992).

Performance measurement is a "mystery… complex, frustrating, difficult, challenging, important, abused and misused" (Sink 1991). Numerous researches have exposed the definitions of terms; performance measurement, performance measures, and performance measurement systems:

Performance measurement has been defined as "the systematic assignment of numbers to entities"(Zairi 1994, Churchman 1959). It can be further defined the function of measurement is to "develop a method for generating a class of information that will be useful in a wide variety of problems and situations" (Churchman 1959).

Performance measures have been defined as "characteristics of outputs that are identified for purposes of evaluation"(Euske 1984). The ideas of performance measures have been further extended as the vital signs of the organization, which "quantify how well the activities within a process or the outputs of a process achieve a specified goal" (Hronec 1993).

Performance measurement systems focus to "integrate organizational activities across various managerial levels and functions"(McNair et al 1989). Hronec, suggests the necessity for integration of performance measurement system as a "tool for balancing multiple measures (cost, quality, and time) across multiple levels (organization, processes and people)"(Hronec 1993).

A paradigm constitutes the worldview of a scientific community (Laudan 1977; Suppe 1974). Central to the Kuhnian argument is the concept of a "paradigm". The paradigm will include a number of specific laws and the shared metaphysical beliefs of the community (Kuhn 1970). In Kuhn's view, the individual scientist's decision to pursue a new paradigm must be made on faith in its "future promise" (Kuhn 1970, p. 158). Furthermore, in his view, science progresses through "paradigm shifts," but there is no guarantee that it progresses toward anything: least of all toward "the truth" (Kuhn 1970, p. 170). Kuhn defines a paradigm as: "an entire constellation of beliefs, values and techniques, and so on, shared by the members of a given community" (Kuhn 1970, p.175). Besides this definition Kuhn mentioned another sense of use he had: a Paradigm also "denotes one sort of element in that constellation, the concrete puzzle-solutions which, employed as models or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal science" (Kuhn 1970, p. 175).

One of the more lasting imprints that New Industrial Management has made in the industrial sector is an increased popularity of performance measurement focusing on improving the productivity. Yet performance measurement it self is nothing new, since already in the early 20th century, some public organizations were using sophisticated models for performance measurement (Williams 2003). Major emphasis has been put in the latest wave of performance measurement is that greater use should be made of non-financial measures such as customers, suppliers, employees, processes, technology, innovation…etc., and that more dimensions of an organization should be measured, not least to counteract short-term approaches. Further instead of looking at the organization internally modern approach is to look at it externally while including the measures to handle internal activities.

Over 150 years ago the Irish mathematician and physicist Lord Kelvin said:

> *When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind… it may be the beginning of knowledge, but you have scarcely in thought advanced to the stage of science* (cited in Tangen 2004 and Fisher 1990).

Sustainability is the number one question as all the industries from SMS (Small and medium Scale) to MN (Multi-National), which are experiencing decreasing resource quality, increasing demand, and environmental constraints. In order to focus attention on continuous improvements (Edson 1988 and Talley 1991) stress the need for performance measurement systems. In addition to meeting cost parameters, the development of performance measurement in management has followed a path that has been influenced by the general push to improve quality and service (Amarathunga and Baldry 2002). To change the focus of an organization, performance measurement is a key agent of change (Brignall 1992). For many organisations a lack of appropriate performance measurement can act as a barrier to change and improvement (Amarathunga and Baldry 2002). This implies a shift in professional commitments to shared assumptions takes place when an anomaly "subverts the existing tradition of scientific practice"(Kuhn 1970 p. 6).

In the world market today to maintain the competitive position and survive in a difficult economic and trading environment from SMS to MS manufacturing organizations have to

streamline their activities with a view to improving quality, service and costs (Bititci 1994). Profit, growth and return on investment are traditionally high-level business performance measures and supported by a large range of other financial measures lead to lack structure and tend to encourage a reactive management style. However, many companies are still primarily relying on traditional financial performance measures with out being influenced performance measurement over recent years (Tangen 2003). Certainly, the traditional performance measures sacrifice current profits for longer-term gain (Ross et al 1993). Hence new assumptions (paradigms/theories) require the reconstruction of prior assumptions and the reevaluation of prior facts. This is difficult and time consuming as it is also strongly resisted by the established community (Kuhn 1970 p. 6).

As a remedy to provide the management team with a set of tools for continuous business improvement and to encourage a proactive management style, it must understand the critical sensitivities and key parameters that are not reflected by the traditional financial performance measures. Hence, alternative, non-financial measures of performance must be defined based on top-level business objectives (Bititci 1994). That is when shift takes place, "scientist's world is qualifiedly transformed and quantitatively enriched by fundamental novelties of either fact or theory" (Kuhn 1970 p. 7).

Performance measurement systems historically developed as a means of monitoring and maintaining organisational control, which is the process of ensuring that an organisation pursues strategies that lead to the achievement of overall goals and objectives (Williams 2004). The implementation of first thorough prototypical performance measurement practices surfaced at the New York Bureau of Municipal Research (NYBMR) after 1906 (Williams 2002, 2003). The research activities at NYBMR constitute prototypical performance measurement with their modern descendents and historical antecedents. This leads to the concept research is " strenuous and devoted attempt to force nature into the conceptual boxes supplied by professional education" (Kuhn 1970 p. 5). Figure 1 below illustrates Prototypical performance measurement framework used by NYBMR.

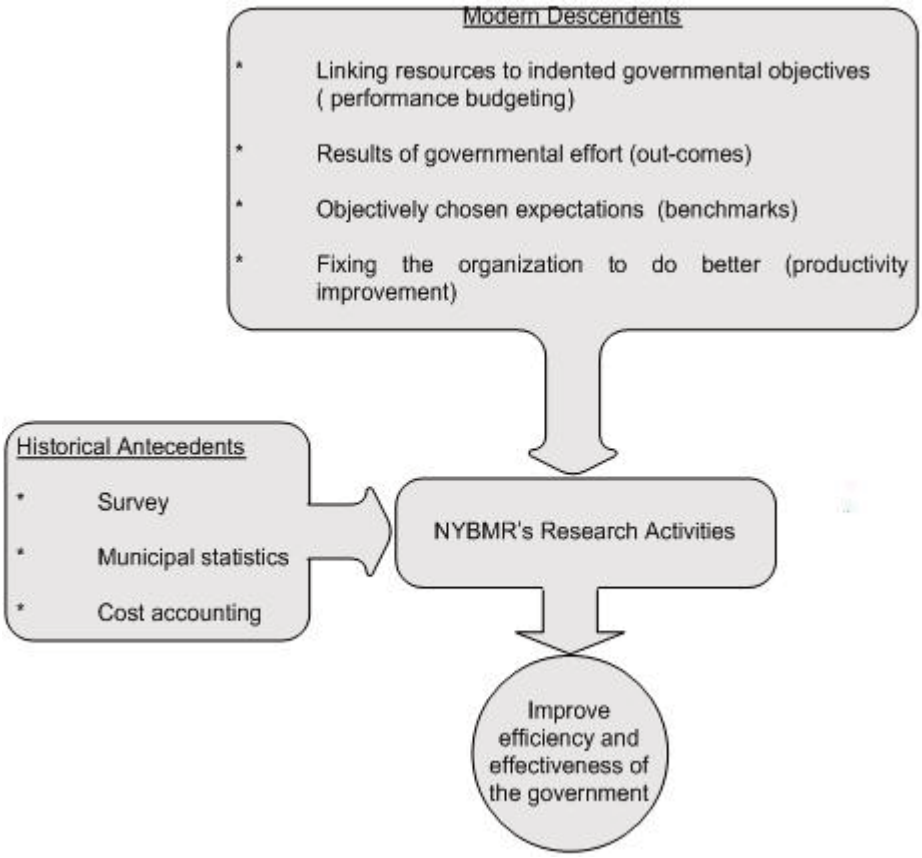

Figure 1. Prototypical performance measurement framework used by NYBMR

First, they were focused on the efficiency and effectiveness of the government focused on linking resources to indented governmental objectives, results of governmental effort, objectively chosen expectations, and fixing the organization to do better. Second, the NYBMR's practices were survey, municipal statistics, and cost accounting that served as the roots of the performance measurement practices (Williams 2002).

The survey. The ideas of Charles Booth's social survey of London to discover facts about poverty (Williams 2004, Converse 1987; Sklar 1991) were imported by leaders of the U.S. settlement house moment led to the social survey of the settlement houses. The social survey was a method to gather detailed data about small areas where Booth's surveys are generally treated as the paradigm shift that prepared the way for modern social research due to data analysis used qualitative devices such as coded maps to reveal demographic information (Williams, 2004). The accepted fact that "a paradigm transforms a group observation always presupposes the existence of some system of expectations" (Popper 1972: p. 344). The word "survey or social-survey" is not the modern word that implies sampling, questionnaires, and use of inferential statistics, which was a comprehensive investigation of the conditions within a small community (Williams 2003).

Municipal statistics. In the 1660s the collection and analysis of statistics were born (Porter 1986). Then they were merged with the study of probability in the 1800s and became a general science of inductive method about 1900 (Porter, 1986; Stigler, 1986). The collection of quantitative social facts developed successfully during the late 1800s, hence the collection of municipal statistics developed in Europe (Williams 2004, Fairlie 1899, 1901, 1908).

Cost accounting. Modern cost accounting spread in the human society following Captain Henry Metcalfe's 1885 text, Cost of Manufactures (Williams 2004, Garner 1954; Previts & Merino 1979). Accounting, record keeping, and needs assessment formed the base of the NYBMR's effort leading to an empirical basis for reporting, budgeting, and productivity improvement.

The NYBMR recommended a system of work planning, scheduling, reporting, and inspection, which, after 1910 became more sophisticated under the influence of scientific management. Hence it became interested in standardization of work processes in two senses: First sense was by defining the best way to do each type of job. Second sense was by setting time and resources standards for work. In addition to that standardization was carried out into financial management with a particular focus on purchasing, where standardization is one of the main practices that the research bureaus borrowed from scientific management (Williams 2004).

Tayler's Scientific Paradigm And Kuhn's Scientific Revolutions

Paradigm shift tend to be most dramatic in sciences that appear to be stable and mature, as in productivity improvements and management at the end of the 18th century. At that time, a typical manager would have very little contact with the activities of the factory. Generally, a foreman would be given the total responsibility for producing goods demanded by the salesman. Under these conditions, workmen used what tools they had or could get and adopted methods that suited their own style of work. By 1881 Taylor had published a paper that turned the cutting of metal into a science. To follow, in 1895, were papers on incentive schemes. A piece rate system on production management in shop management, and later, in 1909, he published the book for which he is best known, Principles of Scientific Management. In this case, the new paradigm reduces the old to a special case where Taylor formalized the principles of scientific management, and the fact-finding approach put forward and largely adopted was a replacement for what had been the old rule of thumb (Daniel 1992).

Near the end of a period of normal science a crisis occurs: experiments give results that don't fit existing theories, or internal contradictions are discovered in these theories. There is alarm and confusion while strange ideas fill in available system and hence eventually there is a revolution. Scientists become converted to a new way of looking at nature, resulting eventually in a new period of normal science (Kuhn 1970). Tayler's identification of scientific management was led to a paradigm shift from the division of labor and the importance of machinery to facilitate labor to describe the management as a science with employers having specific but different responsibilities; encouraged the scientific selection, training, and development of workers and the equal division of work between workers and management, which is "a complete mental revolution on the part of the workingman" and an "equally complete metal revolution on the part of those on management's side… And without this complete metal revolution on both sides scientific management does not exist"(Daniel 1992).

Taylor was not the originator of many of his ideas of scientific management, but was a pragmatist with the ability to synthesize the work of others and promote them effectively to a ready and eager audience of industrial managers who were striving to find new or improved ways to increase performance (Daniel 1992). Where philosophers located the source of the consensual character of science in the scientist's adherence to the canons of logic of scientific inference. Based upon this consensual view of science, science was thought to be strictly cumulative (Laudan 1984). The opposing view of science is that of dissension. That is Taylor's uncompromising attitude in devel-

oping and installing his ideas caused him much criticism. Scientific method, he advocated, could be applied to all problems and applied just as much to managers as workers. In his own words he explained: "The old fashioned dictator does not exist under Scientific Management. The man at the head of the business under Scientific Management is governed by rules and laws which have been developed through hundreds of experiments just as much as the workman is, and the standards developed are equitable" (Web-1). The thesis of incommensurability implies that rival theories are radically incommensurable, e.g. By 1910 International Association of Machinists (IAM) and American Federation of Labor (AFL) had become implacable enemies of scientific management and Taylor was embroiled in a public controversy that would haunt him for the rest of his life as Taylor and his followers had little sympathy for unions (Daniel 1992). The impossibility of full translation between rival paradigms is further exacerbated by the fact that the advocates of different paradigms often subscribe to different methodological standards and have non-identical sets of cognitive values (Kuhn 1977).

Taylor's paradigm was the one of the first to attempt to systematically analyze human behaviour at work and this involved breaking down each task to its smallest unit and to figure out the one best way to do each job. The accepted fact that "a paradigm transforms a group into a profession or, at least, a discipline"(Kuhn 1970 p19). The results were profound. Productivity under the Taylor's paradigm so called *scientific management* went up dramatically. New departments arose such as industrial engineering, personnel, and quality control. There was also growth in middle management as there evolved a separation of planning from operations. Rational rules replaced trial and error; management became formalized and efficiency increased (Daniel 1992).

Despite the economic progress brought about in part by Scientific Management, critics were calling attention to the "seamy side of progress," which included severe labor/management conflict, apathy, boredom, and wasted human resources. These concerns lead a number of researchers to examine the discrepancy between how an organization was supposed to work versus how the workers actually behaved (Daniel 1992). This well explained by Popper, the scientific process begins when observations clash with existing theories or preconceptions. To solve this scientific problem, a theory is proposed and the logical consequences of the theory (hypotheses) are subjected to rigorous empirical tests. The objective of testing is the refutation of the hypothesis. When a theory's predictions are falsified, it is to be ruthlessly rejected. Those theories that survive falsification are said to be corroborated and tentatively accepted (Anderson 1983). The best case study is Hawthorne Studies (The Western Electric (Hawthorne Works) Studies (1923-1933)), which showed how work groups provide mutual support, and effective resistance to management schemes to increase output, where this study found that workers didn't respond to classical motivational approaches as suggested in the Scientific Management and Taylor approaches, but rather workers were also interested in the rewards and punishments of their own work group.

These studies, conducted in the 1920's started as a straightforward attempt to determine the relationship between work environment and productivity (Web-2). The results of the research led researchers to feel that they were dealing with socio-psychological factors that were not explained by classic theory, which stressed the Tayler's paradigm. Hence Hawthorne Studies also helped to see how, when the paradigm ceases to function properly, scientists begin to behave differently and the nature of their research problems changes: an organization is more than a formal arrangement of functions but is also a social system. That is "*the normal-scientific tradition that emerges from a scientific revolution is not only incompatible by often actually incommensurable with that which has gone before*" (Kuhn 1970 P.103).

Evolution of the schools of historical thought and their components

After the scientific management new way of looking at nature resulted during 1910s, eventually a new period of normal science. In the periods of "normal science" characterized by what Kuhn sometimes called a "paradigm" and sometimes called a "common disciplinary matrix" which describes a consensus view: in the period of normal science, scientists tend to agree about what phenomena are relevant and what constitutes an explanation of these phenomena, about what problems are worth solving and what is a solution of a problem (Weinberg 1998), which lasted until, which lasted up to 1980s.

Following studies added much to our knowledge that "when an individual or group first produces a synthesis able to attract most of the next generation's partitions, the older schools gradually disappear" (Kuhn 1970 p.18). The schools of historical thought and their components by decade: **Org. theory prior to 1900**: Emphasized the division of labor and the importance of machinery to facilitate labor, **Scientific management** (1910s): Described management as a science with employers having specific but different responsibilities; encouraged the scientific selection, training, and development of workers and the equal division of work between workers and management, **Classical school** (1910s): Listed the duties of a manager as planning, organizing, commanding employees, coordinating activities, and controlling performance; basic principles called for specialization of work, unity of command, scalar chain of com-

mand, and coordination of activities **Human relations** (1920s): Focused on the importance of the attitudes and feelings of workers; informal roles and norms influenced performance, **Classical school revisited** (1930s):Re-emphasized the classical principles **Group dynamics** (1940s) Encouraged individual participation in decision-making; noted the impact of work group on performance **Bureaucracy** (1940s) Emphasized order, system, rationality, uniformity, and consistency in management; lead to equitable treatment for all employees by management **Leadership (**1950s):Stressed the importance of groups having both social task leaders; differentiated between Theory X and Y management, **Decision theory** (1960s): Suggested that individuals "satisfice" when they make decisions **Sociotechnical school** (1960s): Called for considering technology and work groups when understanding a work system, **Environmental and technological system** (1960s): Described the existence of mechanistic and organic structures and stated their effectiveness with specific types of environmental conditions and technological types, **Systems theory** (1970s): Represented organizations as open systems with inputs, transformations, outputs, and feedback; systems strive for equilibrium and experience equifinality, **Contingency theory** (1980s): Emphasized the fit between organization processes and characteristics of the situation; called for fitting the organization's structure to various contingencies (Web-1). In particular, Kuhn pointed out that the established framework is rarely, if ever, overturned by a single anomaly. When new paradigm is born from old one; it incorporates much of the vocabulary and apparatus that the traditional paradigm had previously employed, though these elements are employed in different ways (Kuhn 1970). This clearly reflects reason that the core concepts of scientific management have not been abandoned and have merely been modified and updated. Hence the core elements of scientific management remain popular today.

The following essays examine the fates of the scientific management pioneers and situation of scientific management in the industry after 1915. "The diffusion of scientific management in society and industry, and the criticisms of a later generation of analysts who had no firsthand knowledge of Taylor or his work. More important, they show that in the United States, as in Europe, scientific management continued to be a stimulus to thinking about the *functions of organizations* and a series of techniques for improving *short-run economic performance*. Because of this dual role, the study of scientific management provides an avenue for understanding the American interest in economic and technical rationalization as well as the evolution of production management and the changing character of industrial work in the middle decades of the century" (Daniel 1992). This short-run economic performance led to the requirement of PM&M systems in the present organizations. That is only when researchers know with precision what to expect from an experiment can they recognize that something has gone wrong. Consequently, *anomaly appears only against* the background provided by the paradigm (Khun 1970 p. 65).

Revolution of Organization Performance

At first Tayler was disappointed with the response to his work because he could talk about a larger, integrated conception of management but most manufacturers wanted solutions to specific problems (Daniel 1992). That clearly analogs with what Kuhn says, to make the new paradigm successful, deliberately restrict the vision and imagination in order to see some particular thing better. Kuhn showed that in doing so science also bound itself to a set of assumptions that it did not even recognize as such. Enough surprising or anomalous results can make the assumptions of a long-held theory visible again, but only if some freethinking scientist pulls back from his hypothesis long enough to look at the big picture. A shared commitment to a paradigm ensures that its practitioners engage in the paradigmatic observations that its own paradigm can do most to explain, i.e., investigate the kinds of research questions to which their own theories can most easily provide answers (Khun 1970 p.13).

Hence the Taylor's scientific management and the related further developments up to 1990s were confined internal to the organization's productivity improvement. After that with Kapaln and Norton's work produced a synthesis able to attract most of the next generation's practitioners, while the previous paradigms gradually disappear leaving their core elements. Those with "older views… are simply read out of the profession. Their work is subsequently ignored when they do not accommodate their work to the new paradigm, they are doomed to isolation or attach themselves to some other group" (Kuhn 1970 p.19). Performance measurement practices with management and hence execution of the organization strategy than formulation of strategy gain their status because they are more successful than their competitors (financial performance measures) in solving a few problems that the group of practitioners has come to recognize as acute. This paradigm-based research is an "an attempt to force nature into the preformed and relatively inflexible box that the paradigm supplies" (Kuhn 1970 p. 24).

Major goals of any organization would be satisfying their customers with greater effectiveness and efficiency than their competitors, where effectiveness refers to the extent to which customer requirements are met, and efficiency is a measure of how economically the organization's resources are utilized when providing a given level of customer satisfaction. This highlights the fact that there can be internal as well as external reasons for pursuing specific courses of action (Slack 1991). Both

of these can be explained with respect to quality-related dimensions of performance focusing on product reliability. High-level of customer satisfaction can be achieved with high product reliability and cost incurred by the business can be reduced when decreasing field failure and warranty claims where former related to effectiveness and later related to efficiency which implies the level of performance business attains is a function of the efficiency and effectiveness of the past action.

Performance attained =f
(effectiveness and efficiency of past action)

Therefore one can simply see a set of metrics used to quantify the efficiency and effectiveness of past actions constitutes performance measurement system. On the contrary this explanation ignores the fact that a performance measurement system (PMS) encompasses a supporting infrastructure that, data have to be acquired, collected, sorted, analyzed, interpreted and disseminated. The measurement process is incomplete, if any of former mentioned activities are missed, in turn informed decisions and actions cannot subsequently take place. Hence more elaborative explanation for PMS: PMS quantifies the efficiency and effectiveness of past actions through the acquisition, collection, sorting, analysis, interpretation and dissemination of appropriate data which enables informed decisions to be made and actions to be taken. In the context of PMS, the information-processing activities are defined as follows (Neely 1998).

- Data acquisition: the process of gathering raw facts
- Data collection: the process of compiling the raw facts into a single data set.
- Data sorting: the process of assigning the individual facts in the data set to meaningful categories so that the data can be analyzed.
- Data analysis: the process of searching for patterns that exist in the sorted data set.
- Data interpretation: the process of explaining the implementations of any patterns that have been identified in the sorted data set.
- Data dissemination: the process of communicating the implication of any patterns that have been identified in the sorted data set.

These definitions are important because in the field of PM, language used is confused. Usually inquiry begins with a random collection of "mere facts" (although, often, a body of beliefs is already implicit in the collection) and during these early stages of inquiry, different researchers confronting the same phenomena describe and interpret them in different ways (Khun 1970 p. 17).

The tentative explanation for the function of measurement to improve organization productivity is to develop a method for generating a class of information that will be useful in a side variety of problems and situations because any scheme of measurement does violence both to reality and to the functional meaning since there are many methods of accomplishing an objective (Churchman, 1959). Therefore, in the present system the achievements are sufficiently open ended to leave all sorts of problems for the redefined group of practitioners and these achievements can be called paradigms (Kuhn 1970, 10). This can be well explained philosophically: "one of the things a scientific community acquires with a paradigm is a criterion for choosing problems that, while the paradigm is taken for granted, can be assumed to have solutions" (Kuhn 1970 p. 37). Doing research is essentially like solving puzzle. Puzzles generally have predetermined solutions. The researcher who is striving to solve a problem defined by existing knowledge and technique is not just looking around. He knows what he wanted to achieve, and he designs his instruments and directs his thoughts accordingly (Kuhn 1970 p. 96). Hence it is safe to assume that every measurement system to decide at the beginning (Churchman 1959).

1. The language of expressing results (language)
2. The objects and in what environment the results will apply (specification)
3. How the results can be used (standardization)
4. How one can evaluate the use of the results (accuracy and control)

Different commentators describe the same concept with different languages where some talk about performance measurements, some about performance matrices, some about critical success factors and rest about key performance indicators. Many of them address former four factors directly or indirectly but often context dependent and, although different phrases have been used to describe the same thing, but the words it self carry an important message. Reckitt & Colman, one of the world's largest pharmaceuticals and household products companies, has decided to use the phrase "*development measures*" rather than performance measures, as it stresses the role of measurement towards the development of organization, rather than to evaluate individual performance ((Neely 1998 p6). The researchers, whose research is based on shared paradigms, are committed to the same rules and standards for scientific practice (Khun 1970 p. 11). Though the distinction not sounds good enough which is useful, as it eliminates some of the perceived threat of PM. Further PM is not only topical in the private sector, but it's value is recognized by the governments and their agencies from early 1900s (Williams, 2002, 2003). In 2000 the fourth annual report on the Governing-for-Results

and accountability project of the Urban Institute, Washington, integrates strategic planning and performance measurement. The basic philosophy behind this effort was the strategic plan defines the performance to be measured, while performance measurement provides the feedback that keeps the strategic plan on target (see, Figure 2) (Dusenbury 2000). In UK, 1992, a white paper on competitiveness, government declared: "To achieve sustainable business success in the demanding world marketplace, accompany must… use relevant performance measures" (UK 1994). Further in United States the National Academy of Engineering stressed: "world-class manufacturers recognise the importance of metrics in helping to define goals and performance expectations for the organisation. They adopt or develop appropriate metrics to interpret and describe quantitatively the criteria to measure the effectiveness of the manufacturing system and its many interrelated components" (Neely 1998 p. 7).

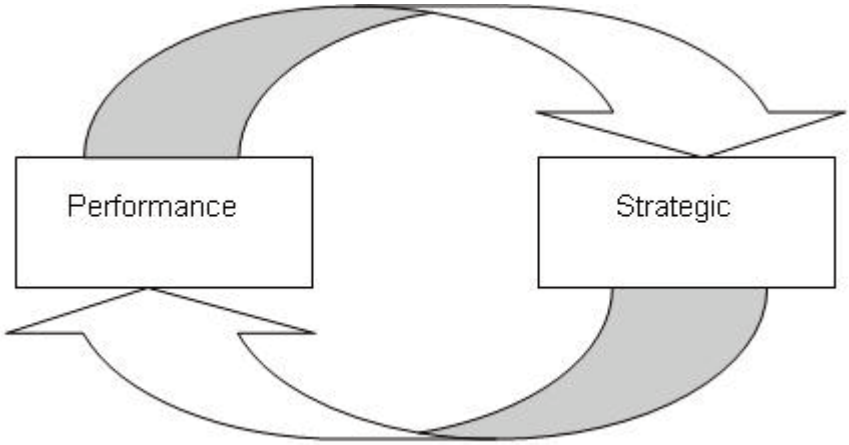

Figure 2. The circle of performance measurement and strategic planning (Source, Dusenbury, 2000)

A New Period of Normal Science

Over the last hundred years, the organizations come a long way in how they measure financial success, hence the work of financial professionals is to be commended and though the innovations such as Activity-Based Costing (ABC), Economic Value Added (EVA)…etc., have helped many organizations make more informed decisions, but the vast majority of organizations fail miserably when attempting to execute their strategies. In fact, "a 1999 Fortune magazine story suggested that 70 percent of CEO failures came not as a result of poor strategy, but of poor execution (Charan and Colvin, 1999). The recognition and acknowledgement of anomalies result in crises that are necessary precondition for the emergence of novel theories and for paradigm change, where crisis is the essential tension implicit in scientific research (Kuhn 1970 p. 79).

After 1990s with the development of private-sector Balanced Score Card (BSC) provided an opportunity of shifting for new mental revolution to look at organization externally: "the BSC translate an organization's mission and strategy into a comprehensive set of performance measures that provides the framework for strategic measurement and management system" (Kaplan and Norton 1996). It measures organizational performance across four balanced perspectives: financial, customers, internal business process, and learning & growth while retaining an emphasis on achieving financial objectives. The BSC provides the necessary elements to move away from the old paradigm to new model in which scorecard results become a starting point for reviewing, questioning, and learning about the strategy of the organization. Here it strives to solve a problem defined by existing knowledge and technique is not, however, just looking around (Kuhn 1970 p. 96). In science, all knowledge claims are tentative, subject to revision on the basis of new evidence. Although science cannot provide one with hundred percent certainty, yet it is the most, if not the only, objective mode of pursuing knowledge (Hunt 1991 p. 200-201). This pursuit is dependent upon the imagination as well as critical analytical skills of the scientist. It is generally believed that the goal of the pursuit is the discovery of truth.

Despite their many shortcomings, financial yardsticks are an entirely necessary evil. This is especially the case in the public and non-profit sectors. But in the era of limited, often decreasing, funding, organizations must consistently tread the delicate balance between effectiveness and efficiency focusing on monetarily responsible manner. New paradigm leads organisations to Improve relationships between performance measures within an (internal) organization and measures outside (External) the organization can strengthen management decision-making.

Interlinking is the process that manages relations between the internal, more objective measures and the external, more subjective measures.

Conclusion

The history of PM&M thought proceeds in jumps and advances by revolutions. Crisis, periods of stagnation, and slow-downs are admitted, but only as perverse effects of the 'metaphysical foundations' and the psychological conditions in which the individual researchers formulated their theories, all factors which do not damage the substance of the scientific element. The interpretation is theoretically appealing, for it capture some fundamental ideas of the philosophy of science such as Thomas Kuhn's thesis that scientific progress is paradigm-dependent. This approach, which views the evolution of knowledge as passing through revolutions and explains the latter as caused by the accumulation of anomalies within the dominant paradigms, seems extremely useful in tackling the evolution of the PM&M concepts. It also helps clarifying several key notions such as how productivity improvement techniques evolved up to present while retaining core concepts related to scientific management techniques such as financial measures.

Further it can be seen at 1900s mostly the governments were doing researches to evaluate their own performance, hence automatically they were looking external to the organization. Where as in 1990s the knowledge is transferring from private sector practices to government sector practises. At the moment Norway, Sweden, US…etc., doing thorough studies on performance evolution where one another developing paradigm is about to emerge: relative performance evaluation (RPE).

Reference

AMARATHUNGA D. and Baldry D., (2002), "Moving from performance measurement to performance management", *Facilities*, Vol. 20, number 5/6, pp. 217-223.

ANDERSON, P.F. (1983), "Marketing, Scientific Progress, and Scientific Method, *Journal of Marketing*, 47, (Fall), 18-31.

BITITCI U. S. (1994), "Measuring your way to profit", *Management Decision,* Vol. 32 No. 6, pp. 16-24.

BRIGNALL, S. (1992), "Performance Measurement Systems as Change Agents: a case for further Rearch", Warwick Business School Research papers, No. 72, Warwick Business School Research Bureau, Warwick.

CHURCHMAN, C.W., (1959), "Why measure?" in Churchman, C.W. and Ratoosh, P. (Eds), *Measurement: Definitions and Theories*, John Wiley & Sons, London.

CHARAN R. and Colvin G., (1999), "Why CEOs Fail", *Fortune*, June 21.

DANIEL, N., (1992) "*Mental Revolution - Scientific Management since Tayler*", Ohio State University Press.

DUSENBURY, P., (2000), Strategic panning and performance measurement, Report urban institute, Governing for Results and Accountability Project.

EDSON, N.W., (1988), "Performance measurement: key to world class manufacturing", APICS 31st Annual Conference Proceedings, APICS, Falls Church, VA, pp. 629-32.

EUSKE, K.J., (1984), *Management Control: Planning, Control, Measurement, and Evaluation*, Addison-Wesley, Reading, MA.

FAIRLIE, J.A. (1899). Comparative municipal statistics. *Quarterly Journal of Economics*, 13(3), 343-353.

FAIRLIE, J.A. (1901). Municipal accounts and statistics in continental Europe. In C.W. Woodruff (Ed.), Rochester Conference for Good City Government and the seventh annual meeting of the National Municipal League (pp. 282-301). Rochester, NY: National Municipal League.

FAIRLIE, J. A. (Ed.). (1908). *Comparative municipal statistics*. *In Essays in Municipal Administration* (pp. 275-285). New York: The MacMillan Company.

FISHER, T.J. (1990), "Business productivity measurement using standard cost accounting information", *International Journal of Operations &Production Management,* Vol. 10 No. 8, pp. 61-9.

GARNER, S. P. (1954). *Evolution of cost accounting to 1925*. Montgomery: University of Alabama Press.

HRONEC, S.M., (1993), Vital Signs: Using Quality, Time and Cost Performance Measurements to Chart Your Company's Future, Amacom, New York, NY.

HUNT, S. D. (1991), *Modern Marketing Theory: Conceptual Foundations of Research in Marketing*, Southwestern Publishing.

KAPLAN, R.S. and Norton, D.P (1996), *Translating Stratergy into Action-Balanced Score card* (Boston: Harvard Business School Press, 1996).

KUHN, T (1970), *The Structure of Scientific Revolutions,* 2nd Ed., Univ. of Chicago Press, Chicago & London.

KUHN, T. (1977), T*he Essential Tension*, Chicago, IL: The University of Chicago Press.

LAUDAN, L. (1977), *Progress and Its Problems,* Berkeley, CA: University of California Press.

LAUDAN, L. (1984), *Science and Values, Berkeley*, CA: University of California Press.

MCNAIR, C.J., Mosconi, W. and Norris, T.F., Beyond, (1989), *the Bottom Line – Measuring* World Class Performance, Business One Irwin, Homewood, IL.

NEELY, A. D., (1998), "Performance Measurement: Why, What and How" Economist Books, London.

POPPER, K.R. (1972), *Objective Knowledge*, Oxford, U.K.: Clarendon.

PORTER, T.M. (1986). *The rise of statistical thinking 1820-1900*. Princeton, NJ: Princeton University Press.

PREVITS, G. J., & Merino, B. D. (1979). *A history of accounting in America—an historical interpretation of the cultural significance of accounting*. New York: John Wiley.

ROSS, S.A., Westerfield, R.W. and Jaffe, J.F. (1993), *Corporate Finance*, 3rd ed., Irwin, Burr Ridge, IL.

SINK, D., "The role of measurement in achieving world class quality and productivity management", *Industrial Engineering*, Vol. 23 No. 6, June 1991, pp. 23-8, 70

SLACK, N., (1991), *The Manufacturing Advantage: Achieving Competitive Manufacturing Operations*, Mercury, London.

STIGLER, S.M. (1986). *The history of statistics: The measurement of uncertainty before 1900*. Cambridge, MA: The Belknap Press of Harvard University Press.

SUPPE, F. (1974), *The Structure of Scientific Theories*, Urbana, IL: University of Illinois Press.

TALLEY, D.J., (1991) *"Total Quality Management – Performance and Cost Measures: The Strategy for Economic Survival,* ASQC Quality Press, Milwaukee, WI.

TANGEN, S. (2003), "An overview of frequently used performance measures", *Work Study,* Vol. 52, No. 7, pp. 347-54.

TANGEN, S. (2004), "Performance measurement: from philosophy to practice", *International Journal of Productivity and Performance Management* Vol. 53 No. 8, 2004 pp. 726-737.

UK May, (1994). Government white paper on competitiveness, quoting RSA Tomorrow's Company Inquiry Report.

Web-1 http://www.accel-team.com/index.html

WEINBERG S., (1998) "Steven Weinberg on scientific revolutions", *New York review of books*, Vol. XLV, No. 15.

WILLIAMS D.W. (2004), Evolution of performance measurement until 1930, *Administration & Society,* Vol. 36 No. 2, May 2004, 131-165.

WILLIAMS, D.W. (2002), Before performance measurement. *Administrative Theory and Praxis*, 24(6), 457-486.

WILLIAMS, D.W. (2003), Measuring government in the early twentieth century. *Public Administration Review,* 63(6), 643-659.

ZAIRI, M., *Measuring Performance for Business Results*, Chapman & Hall, London, 1994.

About the Author

R.M.C. Ratnayake received the BSc degree in Production Engineering in 1999 and MSc in Manufacturing Engineering in 2005 from the University of Peradeniya, Sri Lanka. He is presently a Doctoral Research Fellow at the Center for Industrial Asset Management (CIAM) and Assistant Professor at the Institutt av Konstruksjon og Material Teknologi (IKM), University of Stavanger Norway. His research interests include implementation of decision tools along with performance measurement of industrial assets focusing on asset integrity management for sustainability. His research is focused within the area of offshore technology seeking sustainability in oil and gas asset operations.