UNIVERSITY OF TAMPERE
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A framework for understanding factors affecting the development and application of a predictive performance measurement system

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ABSTRACT

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Performance measurement, although an integral part of regular business operations is back on the current agenda as a topic of great interest. Researchers from multiple functional backgrounds and representing several different academic disciplines are actively examining and evaluating current methods of performance measurement. The theory base of the research area is highly heterogenic and the lack of predictive performance measures is highlighted as a key issue. At the same time, economic globalization is driving increased levels of change and uncertainty in ways never seen before. The need for predictive business insight is greater than ever before.

Predictive performance measurement systems require a robust organizational setting which is explicitly tied into the current internal and external realities of the organization. The nature of the organizational contingencies needs to be considered when a predictive performance measurement system is developed and applied. An organization capable of dealing with the current must evolve a capability to actively impact the operational measurement and management systems meaningfully with the changing external and internal realities facing the organization. A reliable and robust forward looking capability is an additional dimension of a quality performance measurement system in an environment, where the primary processes of an organization are already in general control.

An organization must accept the inherent uncertainty of the current marketplace. As a response an organization needs to build a capability to understand the source and nature of the uncertainty which impacts its processes and causes their outcomes to vary. This process variation can be leveraged as a basis to enable predictive business insight. An organization needs to also develop a language which it can apply in its effort to integrate the measurement world and the real world, bringing the financial and non-financial managers closer to each other to enable the delivery of predictive business insight. Recognizing the social nature of predictive performance measurement and the operational transformations of financial targets are suggested as responses to create the joint language.

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In Helsinki, 22nd of May, 2008

Martti Nurminen

CONTENTS

When the future is viewed as predictable, organizations do well to send their top leaders off on a retreat and develop a long-range plan for realizing that vision.

T. J. Tetenbaum

1 INTRODUCTION

1.1 Motivation and the relevance of the research

The ability of a corporation to link strategy with execution is one of the fundamental critical success factors for meeting its business objectives. Mintzberg[1] holds the position that, strategy can only be considered to exist, when one is able to recognize a consistent pattern of decisions and actions within a firm. Further, he makes a clear distinction between intended and realized strategy. Intended strategy is characterized as "the determination of the basic long term goals and objectives of an enterprise and the adoption of courses of action and the allocation of resources necessary for carrying out these goals." Realized strategy is defined as "a pattern in a stream of decisions". Whereas the intended strategy is static by nature – it reflects a one time decision. The concept of realized strategy is dynamic by nature and it represents a stream of decisions and consequent actions, where previous decisions, actions and the effects of the actions have an impact on future decisions. When looking into this dynamism, we can question how well the corporation is able to turn its intended strategies into realized ones, and whether the series of decisions and actions support meeting its business objectives. Or, we can question how early and thoroughly the corporation is able to sense the changes in the competitive environment, adjust its intended strategy, and maintain the momentum to meet its business objectives in the future.

Traditionally, strategy formation is conducted as part of a planning cycle and often disconnected from strategy execution. This bipartition results in the evaluation of intended and realized strategy in isolation of each other. The common denominator for them, however, is the real-time competitive environment where they co-exist. This real time interplay offers a demanding challenge to achieving quality decision making and on the associated execution of those decisions. Further, the importance of relevant,

[1]Mintzberg (1978)

real time and informed decision making and execution can be argued to have grown based on the increased speed of ongoing changes in the competitive landscape, including political, technological and cultural factors driving economic globalization and integration in unprecedented ways.[1]

When we consider the challenge the increasing rate of change poses to decision making and execution, the role of meaningful information becomes ever more important. Given the volume of data available in the modern corporate environments, defining which data is registered and how, determining the way the data is processed and consolidated and how the data is will be analyzed and summarized into pertinent information for decision makers is of paramount importance. Consequently, the requirements of efficient and effective decision support processes are subject to exactly the same external pressures caused by the changing competitive landscape as are the strategy formation, decision making and strategy execution processes themselves.

In response to the changing competitive environment and the increasing pressure to move towards more quality decision support processes, the management control system frameworks have experienced a substantial evolution over the past two decades. The starting point for this development can be traced back to the arguments of Johnson Kaplan[2] who suggested that the principles of management accounting needed a substantial revision or that management accounting needed to be abandoned completely. Also, before Johnson and Kaplan published their criticism, the traditional performance measures had already received significant negative feedback and were regarded obsolete. The traditional measures of performance were considered to e.g. encourage short-termism[3], lack strategic focus[4] and to encourage local optimization[5]. As a result, a substantial number of multidimensional frameworks have been developed and we have seen several developments in the areas of strategy maps, business models and cause and

[1]Please see e.g. Berger 2006, Morrison 2006, Palmisano 2006 and Perez 2002 for more a more extensive review on political, technological and cultural factors driving economic globalization and integration.
[2]Johnson and Kaplan 1987
[3]Banks, R.L. & Wheelwright, S.C. 1979
[4]Skinner, W. 1974
[5]Hall, R.W. 1983

cause and effect diagrams to capture changing business dynamics in a more robust way[1]. The term performance measurement can be considered as a common denominator for all of these frameworks, as they are used to measure and manage performance in corporate environments. Notably, the development of the different frameworks has been the result of research conducted by academics with diverse functional backgrounds. Researchers in accounting, operations management, marketing, finance, economics, psychology and sociology are all working in the field to advance the research in performance measurement; however, they are doing so independently, inside their academic discplines[2]. This is a weakness as well as a strength associated with the research on performance measurement: the theoretical premise is rich and vast but one that is based on each academic discipline examining the field of research from its own perspective.

Another acknowledged issue in performance measurement research, is that performance measurement systems often lack a robust, forward looking, predictive capability. Neely, Gregory and Platts[3] point out, that a key item in the performance measurement research agenda is the identification and/or development of predictive performance measures. Unahabhokha, Platts and Tan[4] report, that even though the significance of the link between leading and lagging indicators is well recognized, there is very little work on how the leading indicators could be used jointly to forecast the future. Or, how can they be turned into predictive performance measures of future performance. Wilcox and Bourne[5] argue that while the performance measurement literature often refers to the concept of prediction, the question of how to predict remains unclear whereas Hope[6] recognizes forecasting as an essential tool for leading organizations and business managers to support their decision making. I.e. the importance of predictive performance measurement is well recognized but its theoretical premise and practical applications remain not unified.

The diverse theoretical premise of performance measurement is vast and rich. Multiple definitions exist in the literature. The concepts of performance and measurement

[1]Please see Wilcox, M. & Bourne, M. 2003, pp. 806-809 for an overview of the different models.
[2]Neely, A. 2007
[3]Neely, A., Gregory, M. and Platts, K. 2005
[4]Unahabhokha, C., Platts, K. and Hua Tan, K. 2007
[5] Wilcox, M. & Bourne, M. 2003
[6] Hope, J. 2007

themselves, combined with the ever more dynamic and uncertain competitive landscape and the academically and operationally recognized need for better predictive measures of performance create the premise for this research. The purpose of this research is to assemble a framework for understanding factors affecting the development and application of a predictive performance measurement system. The research includes the analysis and synthesis of theories underlying performance measurement, theories about performance measurement itself and its linkages to contingency theory as well as considering the theoretical aspects of dynamism, uncertainty and prediction in the context of performance measurement. The basis of the research is that before one can justify and construct a framework for understanding factors affecting predictive performance measurement, one has to know thoroughly the concepts of performance and measurement from theoretical perspective as well as to recognize the theoretical conditions of performance measurement validity. First, focus will be given to theoretical underpinnings e.g. definitions and dimensions of performance, measurement theory and conditions of theoretical validity of measurement, to create the premise. Then, the theoretical and academic considerations around issues of performance measures will be looked at. Next, to place performance measurement into a context, the interaction between the contingency theory and performance measurement is analyzed. Last, factors representing the dynamism of the changing environment or reality, will be introduced before closing the loop of logical reasoning with analysis of the theoretical premise of prediction and performance measurements. Figure 1 displays a fundamental view of the factors affecting the development and application of a predictive performance measurement system.

The lower part of the Figure 1 directly links to section 2 of the research, while the upper part of Fig. 1 describes a three dimensional corporate environment. The x-axis indicates static vs. dynamic environment; the y-axis indicates contingent vs. non-contingent world; and z- axis represent certainty vs. uncertainty. Each axis has a direct link into the theoretical components of the research. The x and z –dimensions are covered in section 4 of the research while y –dimension links back to section 3. The interconnected nature of the axes and their relevance for understanding the factors affecting the development of a predictive performance measurement model will be described in section 5.2 of the research

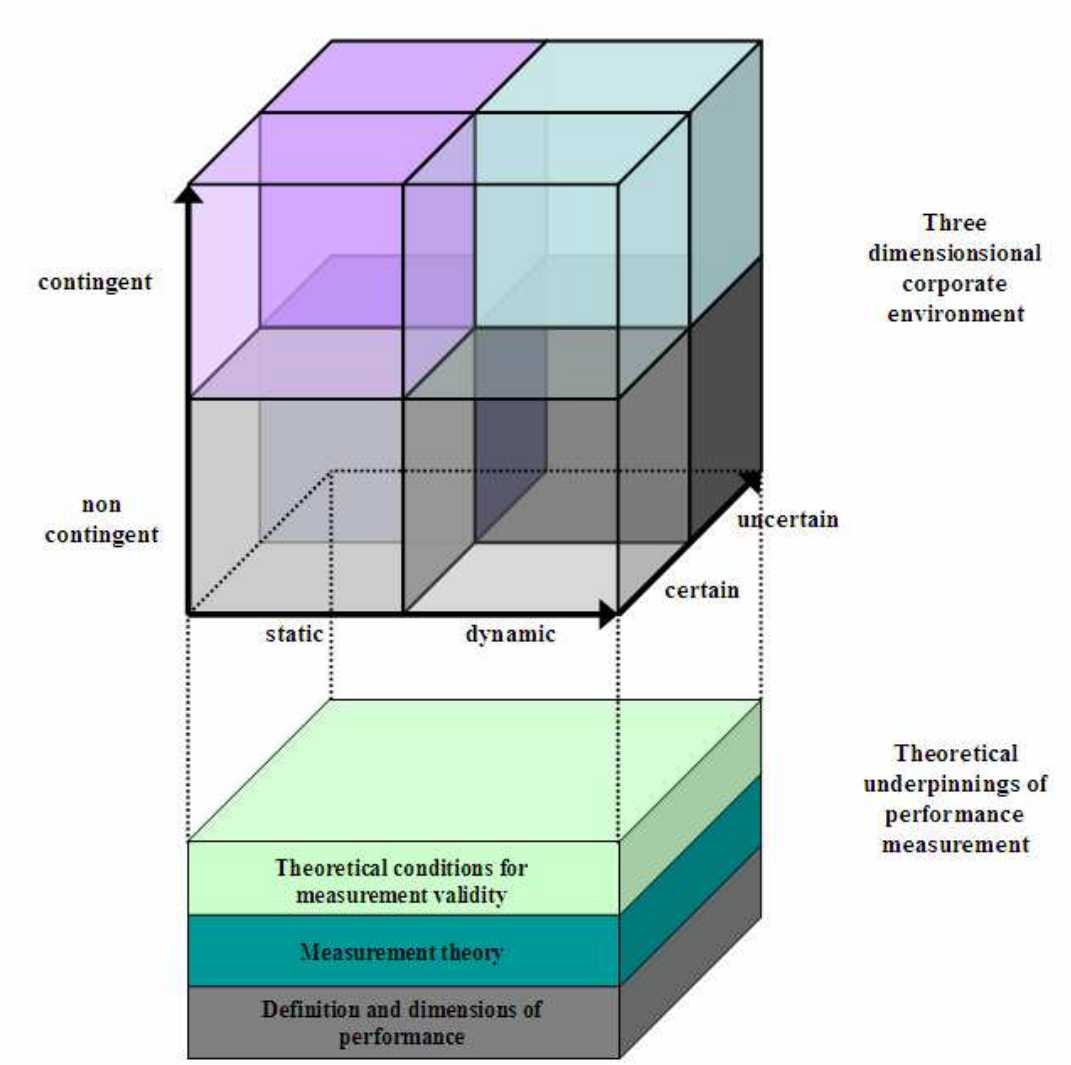

Figure 1 A fundamental view of the factors affecting the development and application of a predictive performance measurement system

The relevance of the research can be looked at from several angles. First, considering the wealth and breadth of academic research that has been published over the last decade about performance measurement and, with the ever increasing speed of change during the last decade, the subject remains current and relevant. There is startling lack of research on the areas of prediction and forward looking capabilities of performance measurement systems. This provides continued motivation for this research. Further, the recognized challenge in the field of performance measurement research is the heterogeneity of its theory premise. This research follows the trails of the leading academics working in the field and seeks to analyze and synthesize existing theories. Consequently, the research is an effort to advance the findings by bringing together a

number of scientific articles from different areas of performance measurement, i.e. theoretical premises impacting performance measurement including individual measures of performance, contingency theory, dynamism and uncertainty, and prediction.

Second, as a consequence from the first target, this research has practical applications for organizations struggling with the challenges of measuring and predicting performance in corporate environments in the most relevant manner. Corporations have to understand the premise of their performance measurement systems and the value of those systems. This research aims at increasing that understanding. The research looks for business alignment of the measurement systems and for ways to bring non-financial managers closer to financial managers through assembling an end to end, closed looped framework for understanding factors affecting the development of a predictive performance measurement system. If successful, the predictive performance measurement system can be used as a joint communication and argumentation vehicle in live environments to increase understanding about the complexity of the basis of performance measurement and in turn help to turn this increased understanding into more reliable and valuable ways of measuring and predicting performance.

Third, this research indirectly touches one of the most pertinent topics in the world of business today: the consequences of economic globalization. In the global economy, the speed of change and the levels of dynamism and uncertainty are unprecedented. This sets completely new requirements for decision support. We are experiencing faster and bigger changes in a broader, competitive landscape than ever before. This allows less time for management to adjust strategies and operations. The better a corporation understands the premise of its performance measurement systems and the premise of what is required to create a predictive system, the better are its capabilities of being able to turn its intended strategies into realized ones and the better its chances to be able to foresee the necessary adjustments for its intended strategy. The corporation will be better able to react as well as to take proactive measures to stay competitive.

1.2 Research problem and the target of the research

The research problem is based on constructing a framework of factors affecting the development and application of a predictive performance measurement system. Solving the problem is based on logical reasoning, analysis and synthesis of academic literature. The research problem can be divided further into tasks:

- Analyzing and synthesizing the theories and academic literature around the definitions and dimensions of performance
- Analyzing and synthesizing the theories and academic literature around measurement theory
- Analyzing and synthesizing the theories and academic literature around theoretical conditions for measurement validity
- Analyzing and synthesizing the theories and academic literature around individual performance measures
- Analyzing and synthesizing the theories and academic literature around contingency theory in relation to performance measurement
- Analyzing and synthesizing the theories and academic literature around on how dynamism and uncertainty affect performance measurement and performance measurement systems
- Analyzing and synthesizing the theories and academic literature on how performance can be predicted

Solving the problem successfully will require the researcher to analyze and synthesize existing theories in a way which enables creating something new as a result. The key products of this research are the synthesis of the theoretical components, the constructed framework, an increased understanding about the premise of predictive performance measurement, a description of how the constructed framework can be used to develop predictive performance measurement systems and finally, how all the products are brought together to enable performance prediction in a relevant, valuable manner. As such, the products of the research are the targets of the research. The purpose of the research is to create knowledge and increase understanding as well as analyze and synthesize existing theories and knowledge.

This research *excludes* the individual level compensation aspects, i.e. the linkages between performance measurement systems and possible performance related payments made to employees will not be analyzed. The exclusion is recognized to be a significant one in the context of the target of the research but the scope of the thesis simply forces the respective exclusion.

The framework to be constructed is conceptualized at the corporate not the individual level. It is recognized that at the end of the day, it is the people or individuals, who make up the organizations. Also the cultural considerations are understood at a nation, not at an individual level.

The agency theory related considerations are excluded form this research. I.e. individuals are always assumed to act on the best interest of a corporation.

The mathematical aspects of prediction are excluded as well. The research looks at prediction through business economics, not through theories of calculus. Of course, when any measurement is involved, some calculation is necessary. However, it is the point that is made by Wilcox and Bourne[1]: "…the concept of prediction has been taken over by mathematicians and made it a very complex process to apply and understand." that is the relevant one here. All issues related to the relationship of performance measurement and information technology are excluded as well from the scope of this research.

1.3 Literature survey

The literature survey is presented in the order of how the theoretical components of this research will be analyzed.

[1]Wilcox, M. & Bourne, M. 2003

Performance defined

Oxford English Dictionary will serve as a starting place. Folan, Browne and Jagdev (2007) have completed an extensive review about the meaning of the word performance especially in the context of business research. Baird (1986), Corvellec (1995), Lebas (1995), Lebas and Euske (2007), Meyer (2007), and Neely, Gregory and Platts (2005) have also all contributed in defining what performance means in the business context and what dimensions it can be seen to have.

Measurement theory

Krantz, Luce, Suppes and Tversky (1971) will serve as the basis for the analysis of the main axioms of measurement theory. Pike and Roos (2007) will offer the overview of different measurement scales while Pike and Roos (2004) provide the requirements for business measures derived from the measurement theory. M'Pherson and Pike (2001) provide the presentation of the measurement process.

Theoretical conditions for measurement validity

Ryan, Scapens and Theobald will provide the basis for the ontological and epistemic considerations. Norreklit, Norreklit and Israelsen (2006) will serve as the basis for the analysis over the different dimensions of reality. Norreklit, Norreklit and Mitchell (2007) extend on the issues around the validity of performance measurement systems.

Performance measures

Neely, Gregory and Platts (2005) offer the analysis of the quality, time, cost and flexibility aspects of measures while Brignall and Ballantine (1996) offer an alternate, more detailed, categorization. Neely, Richards, Mills, Platts and Bourne (1997) identify also the importance of considering the behavioural aspects of measures and suggest a performance measure record sheet to answer the question of how does a good measure look like. Bourne, Mills, Wilcox, Neely and Platts (2000) provide an extensive list of academic research in the area of linking measures to strategy.

Performance measurement and contingency theory

Donaldson (2000) offers the general theoretical premise about the contingency theory. Chenhall (2003) serves as the key article in leading the way into the analysis of different aspects of how performance measurement and contingency theory interact. Bruns and Waterhouse (1975), Merchant (1981) and Chenhall and Morris (1986) contribute to the analysis over the relationship between organizational structure and performance measurement. Child and Mansfield (1972) provide the basis for the interaction of size and performance measurement while Lanfield-Smith (1997) provides a good overview of how strategy and performance measurement can be seen to interact. Hofstede's (1984) work is the central premise in looking into the cultural contingencies of performance measurement.

Dynamism, uncertainty, prediction and performance measurement

The analysis of how dynamism affects performance measurement and the evolution of performance measurement systems starts with Kennerley and Neely (2002) offering their view on the factors affecting the evolution of performance measurement systems. Meyer and Gupta (1994) provide valuable insight on the performance paradox, where measures lose their effect over time. Bititci, Turner and Begemann (2000) describe the dynamics of performance measurement systems and the changing basis of performance measurement respectively while Waggoner, Neely and Kennerley (1999) provide an interdisciplinary review about the same matter. Kennerley and Neely (2003) introduce two important questions which need to be answered on a way to ensure performance measurement systems remain valid even in a dynamic environment.

Palmer and Parker (2001) provide the supporting research regarding the analysis of uncertainty and prediction in performance measurement. They argue that the deterministic assumptions of traditional performance measurement are inherently flawed and would need to be replaced by the uncertainty principles of physical sciences. Shewhart (1931), Unahabhokha, Platts and Tan (2007) and Wilcox and Bourne (2003), provide the theoretical premise of analyzing prediction and performance measurement. Fink, Marr, Siebe and Kuhle (2005) offer extensions for prediction, including the strategy alignment of predictive processes.

1.4 Research methodology and method

Creswell[1] sees three different paradigms approaching a research task – historic, qualitative and quantitative. According to him, the paradigms help in understanding assumptions about the world, ways of conducting science, as well as what justified problems, solutions and evidences there might exist. As the target of the research is to increase understanding and to create a multidimensional and general framework about the research area, the qualitative paradigm is chosen. According to Creswell[2], the qualitative paradigm represents an interpretive and naturalistic approach where the reality is considered to be subjective and experimental and where decisions are being constructed and models and theories being developed to increase understanding. Further, the qualitative paradigm assumes that not necessarily all the variables of the models under research are always known ex ante and that the previous researches and theories might require supplements. On the other hand, it's Olkkonen[3] who points that a research can include characteristics both from positivist (quantitative) and hermeneutic (qualitative) philosophies of science. This is an important consideration for this research, which assumes a conceptual research method - as the premise of conceptual research can be tied back to both positivist and hermeneutic traditions[4]. According to Näsi[5] the purpose of the conceptual research method is the construction of systems of concepts. Neilimo and Näsi[6] consider that conceptual research results new purpose, mission or other need[7]. Generally, the results of a conceptual research method can be either descriptive or normative[8].

This research is composed of an *analysis* phase which will compose the theoretical frame of reference per sections 2., 3. and 4. of the research. *Synthesis* is used in section 5.1 where the relevant theories analyzed in the former sections will be worked out into formats which will enable the construction of the framework in section 5.2 and the *logical reasoning* about the dependencies and the interactions between the different factors of the framework from a predictive performance measurement perspective in sections 5.3 and 5.4.

[1,2] Creswell, J.W. 2003
[3, 4, 7] Olkkonen, T. 1994
[5] Näsi, J. 1983
[6, 8] Neilimo, K & Näsi, J. 1980

1.5 Structure of the research

The phases of the research are displayed below in Figure 2. It displays the logical structure described in the Introduction. The research analyzes the existing theories in currently available research. The premise is built in a stepwise manner. The target is to be able to apply and leverage each of the components of the theoretical frame of reference, when the framework for understanding factors affecting the development of a predictive performance measurement system is built in section 5 of the research.

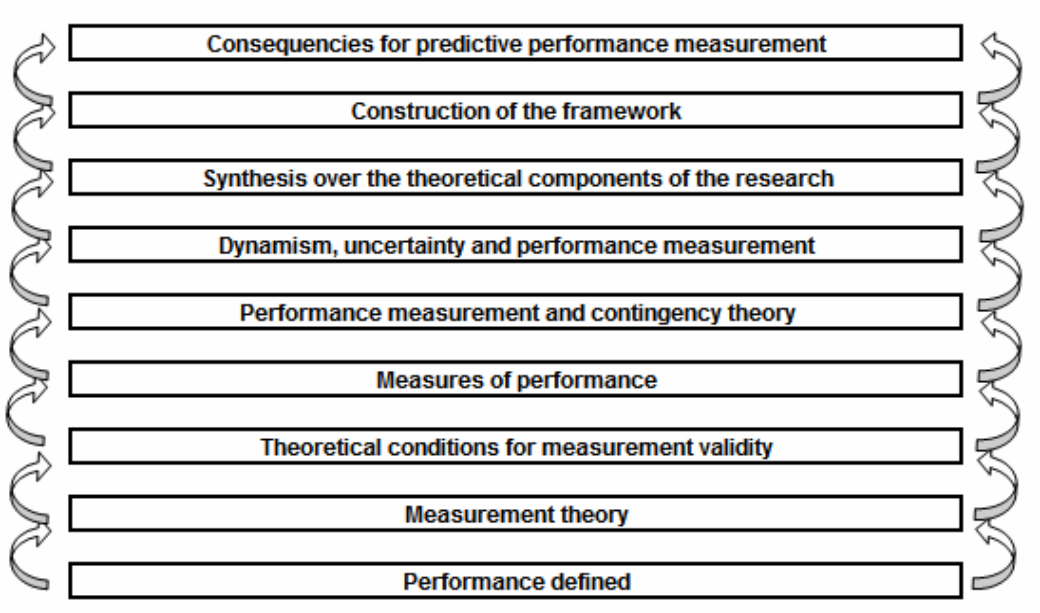

Figure 2 The phases of the research

Performance will be first defined according to the Oxford English Dictionary. Then, the concept of performance will be analyzed in the context of business performance and several academic view points will offered. Measurement theory is a branch of applied mathematics. The premise of the theory, its main axioms, propositions, different measurement scales as well as the consequent requirements for business measures derived from the theory will be analyzed. A presentation of a measurement process will be also described.

In the section 'Theoretical conditions for measurement validity,' ontological and epistemic considerations are introduced. I.e. what do we consider to be real and how can

we acquire knowledge. The respective considerations will be of fundamental value as key elements for the research. Further, a concept of reality[1] will be reviewed and analyzed as another key element for any measurement to be valid. The different aspects of this reality concept will be covered and their relevance explained.

The 'Measures of performance' section will outline key dimensions of measures offered by academic researchers working in the field and published in academic journals. Measurement aspects such as quality, time, cost, flexibility will be analyzed. Particular emphasis will be made on creating a clear distinction between leading and lagging, i.e. non-financial and financial measures of performance.

In the section 'Performance measurement and contingency theory', different contingencies and their impacts to performance measurement systems will be analyzed. Strategy, national culture, organizational structure and size contingency factors will be analyzed.

The last building block of the theoretical frame of reference is composed out of dynamism, uncertainty and prediction. How dynamism and uncertainty affect performance measurement and measurement systems and how performance can be predicted will be reviewed. Applying physical science uncertainty principles in understanding performance measures will be considered as well.

As a next step, a synthesis and preliminary components of the final framework will be composed. Then, the framework will be introduced and its relevance and interaction with predictive performance measurement argued.

[1]Reality as defined in Norreklit H. & Norreklit L. & Israelsen, P. 2006

2 THE PREMISE OF PERFORMANCE MEASUREMENT

2.1 Performance defined

Performance is a challenging concept. It is widely used in business but very rarely, if ever, explicitly defined. The same circumstances apply in research: the word performance is most often a placeholder and the context defines its meaning. It does not have only one definition. It has many.[1]

Oxford English Dictionary (OED) provides 15 different meanings for the word performance. Folan et al.[2] have categorized the meanings OED provides and present four primary meanings for the word performance:

i. Related to the doing of an action or operation
ii. A set of (fur) trimmings
iii. The carrying out, discharge, or fulfilment of a command, duty, promise, purpose, responsibility, etc…; execution, discharge. Frequently opposed to promise
iv. The action of executing or interpretation.

Folan et al.[3] themselves define performance through its selection and arrangement characteristics and elemental qualities. Selection and arrangement characteristics of performance govern its relevance in terms of a particular environment with a given relevant objective and are reduced to recognisable characteristics, while the elemental qualities refer to the static and dynamic characteristics of performance.

Lebas and Euske[4] have developed a step by step process where they show performance to be a social construct, which is a result of recognition and sharing of a causal model. Their development leads them to state that performance is valid only in a decision making context and is therefore valid only for a given set of decision makers.

[1] Please see e.g. Folan et al. 2007, Lebas 1995, Lebas and Euske 2007, Meyer 2007 and Neely et al. 2005
[2, 3] Folan et al. 2007
[4] Lebas and Euske 2007

Baird[1] defines performance through action orientation and argues it must be expressed by a verb, while Corvellec[2] extends the position of Baird's and argues performance refers simultaneously to the action, to the result of the action and to the degree of how successful the action can be argued to be. Neely et al.[3] define performance as a function of effectiveness and efficiency, where effectiveness is the extent to which customers' requirements are met and efficiency is the measure of how economically company's resources are used on producing a given level of effectiveness.

Lebas[4] presents a diversity of criteria for defining performance:

i. Employment creation
ii. Societal good
iii. Security of employment for the firm's personnel
iv. Providing a satisfying return to corporate headquarters
v. Innovativeness in processes and products
vi. "Customer" satisfaction
vii. Growth of market share
viii. Environmental "contribution(s)" (positive as well as negative)
ix. Technological leading edge

Lebas[5] concludes that performance is about capability and future. It cannot be defined objectively; it needs to be positioned in a conceptual context.

2.2 Measurement theory

"Measurement is the process of assigning numbers to things in such a way that the relationships of the numbers reflect the relationships of the attributes of the things being measured."[5] Measurement theory is a branch of applied mathematics. The core of the theory supports that a measurement is not the same as the object being measured but a

[1]Baird 1986
[2]Corvellec 1995
[3]Neely et al. 2005
[4]Lebas 1995
[5]Pike and Roos 2007

representation about it. Consequently, in order to conclude something about the object, it's fundamentally important to consider the nature of the relationship between the attribute and the measurement.[1]

Krantz et al.[2] present the main propositions of measurement theory:

i. Numerical representations of quantities and laws of nature are determined by the set of axioms for corresponding empirical systems – algebraic systems with some sets of relations and operations
ii. The numerical representations are unique up to some sets of allowable transformations (such as a change of measurement units)
iii. All physical attributes may be embedded into the structure of physical quantities
iv. Physical laws are simple, because of the procedure of simultaneous scaling of all attributes involved in the law
v. The same axiomatic approach is also applicable not just for physical attributes and laws but for many other attributes from other domains (such as psychology), using polynomial and other representations.

The first proposition states that measurement can be regarded as a construction of scales from empirical relational structures of interest into numerical relational structures that are useful. The second proposition is about the different measurement scales – a classification of measurement in terms of permissible transformations. The third proposition defines that the attributes can be regarded as part of the quantities. The fourth proposition describes the assumption of simultaneous scaling where the attributes move together and finally, the fifth proposition describes the extension of the same axioms into measurement of non-physical attributes.[3]

Pike and Roos[4] provide on overview of different measurement scales (Table 1). They make the point that only ratio or absolute scales are proper for business performance measurement as they have a meaningful zero. Without the meaningful zero, it is not possible to understand what the measure is telling.

[1, 4] Pike and Roos 2007
[2] Krantz et al. 1971 in Pike and Roos 2007
[3] Krantz et al. 1971

Name of scale	Typical description	Transformations	Allowed statistics
Nominal or categorical	A classification of the objects	Only those that preserve the fact that objects are different	Descriptive: frequencies, mode, information content; associative: chi-square
Ordinal	A ranking of the objects	Any monotonic increasing transformation, although a transformation that is not strictly increasing loses information	Descriptive: median, quantiles and quartiles; associative: Spearman's rank order correlation coefficient; Kendall's tau, rho
Interval	Differences between values are meaningful, but not the values of the measure itself	Any affine transformation t(m) = c*m + d, where c and d are constant; the origin and unit of measurement are arbitrary	As above, plus arithmetic mean, standard deviation
Ratio	There is a meaningful "zero" value and the ratios between values are meaningful	Any linear (similarity) transformation t(m) = c*m, where c is constant; the unit of measurement is arbitrary	As above, plus geometric mean
Absolute	All properties reflect the attribute	Only one-to-one transformations	All

Table 1 Description of scales[1]

[1]According to Pike and Roos 2007

Measurement theory also poses some specific requirements for business performance measures. These are: completeness, distinctness, independence, agreeability and commensurability.[1]

Completeness means that if the purpose is to measure the whole company, then all the attributes of the company which are to be measured need to represent the company as a whole as a complete entity. The meaning of each attribute needs to be explicitly defined and the aggregate meaning of the attributes to be measured needs to reflect all the resources of the firm as well as how they are used in the company. The purpose of d*istinctness* is to eliminate double counting. An attribute can be used for measurement, when it is distinct, i.e. its meaning has to be injective and there is nothing in the meaning that would be measured within the meaning of another attribute. *Independence* refers to the relationship of the units being measured. It says that the mathematical conditions of commutativity, associativity, transitivity, monotonicity and the Archimedian conditions has to be satisfied. As a consequence, it is safe to perform aggregation over individual measures of performance.

Agreeability relates to the mapping between the numerical system and the empirical world. It calls for the meaning of the attribute in the empirical world to be fully reflected in the performance measure in the numerical system where the actual act of measurement happens. The meaning of the attribute has to have the same meaning in both the empirical world and the measurement world.

Commensurability means that for the measurement and the consequent aggregation to be valid, the attributes have to be observed using a ratio scale and be normalized into a common scale. If this is not done, the conclusions and the consequent decisions will be meaningless. It is also shown that in terms of physical measures, the right scale to use is easy to select. However, as many of the business performance measures are not simple and do not display themselves as easily observable, ratio scale techniques must be used in data collection.

[1] Pike and Roos 2004

M'Pherson and Pike[1] define a measurement process (Figure 3) applying the principles of measurement theory. It consists of a mapping model, a primary measurement and of a multidimensional measurement.

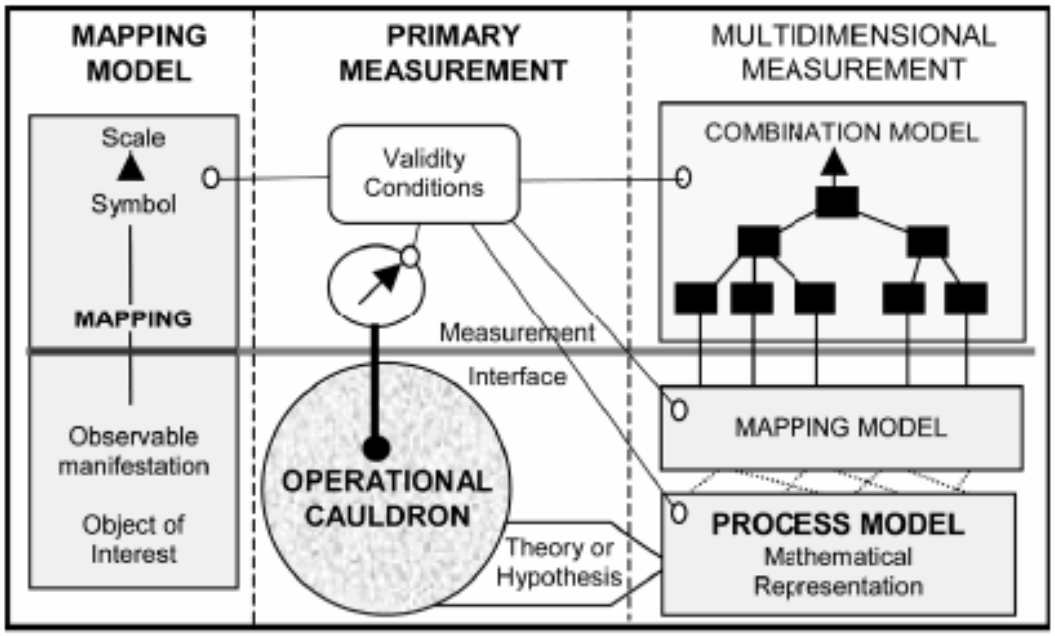

Figure 3 The Measurement process[2]

The mapping model, or a homomorphism, is the construction of empirical relational structures into numerical relational structures. The primary measurement is a one-to-one mapping of an attribute, e.g. weight to kilos or units per hour. The multidimensional model is a many-to-one mapping and is based on the primary measurements. The purpose of the multidimensional measurement is to reflect the underlying primary measures and their varying leverage of a combination of factors in the model which in itself functions as a combination engine in the process.[3]

2.3 Theoretical conditions for measurement validity

The act of measurement can be considered to be a tool in the process of acquiring knowledge. Plato and his followers defined knowledge as a justified true belief[4].

[1, 2, 3] M'Pherson and Pike 2001
[4] Ryan et al. 2002
[5] Audi 1988 in Ryan et al. 2002

Audi[1] summarizes the sources of our beliefs: objects or events may be perceived (a perceptual belief), facts may be remembered (a memorial belief), belief may be formulated through introspection (an introspective belief), a process of reason (a rational belief), and a process of induction (an inductive belief) or a testimony of others (a testimonial belief). Fundamentally, all the sources reduce down to two: beliefs and consequent knowledge are acquired through a perception about the appearance of an external object or through a process of reasoning which is grounded within rational processes of the individual subject[2]. As a basis for these epistemological considerations, Ryan et al.[3] 2002 present a subject-object divide (Figure 4). The figure displays the two fundamental but alternate ways to acquire knowledge. On the left hand side the process is based on perception, often referred to also as empiricism and on the left hand side it's based on reasoning, often referred to also as rationalism.

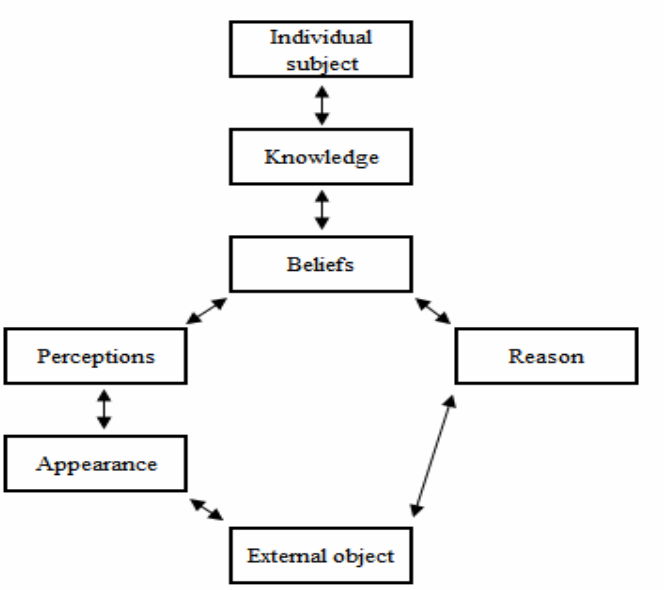

Figure 4 The subject-object divide

The idea of acquiring knowledge through reasoning and rationalization can be traced back to Socrates and Plato. If one considers an organization as an external object, according to Socrates and Plato, it is an entity which does not exist in space or time but can be purely recognized and analyzed through reasoning. Aristotle did not agree with Socrates and Plato and argued that objects do have a spatial-temporal existence.[4]

[2, 3, 4] Ryan et al. 2002
[1] Audi 1988 in Ryan et al. 2002

Classical empiricists, followers of Aristotle, formulate their position based on three rules:

i. Certainty of belief in what we know can only be approached through perception
ii. Ultimately all knowledge is derived from perception through our senses
iii. In the realm of discourse statements are either true of false because of the way the world is or because of some formal properties of the language we use.[1]

The first rule confirms that a belief has to be justified by experience or by logically or mathematically derived implications of experience based on perception about an object. If it is not, it is meaningless. The second and the third rules confirm that the beliefs about the world cannot be justified by reason alone.[2]

The nature of measurement also raises the question about what can be considered as true knowledge, i.e. what is real and what is the reality? This question finds its answer in ontology, the study of existence.

Reality is focused on the construction of existence in objects. According to the ancient Greeks, one can note two alternate views about the reality: realism, where reality subsists within objects or idealism, where reality subsists within the mind of the subject. Realism is the common-sense view where the object has a reality independent of our perception of it. It is evident in the literature that the general belief in a mind-independent reality is very strong. Idealists argue that what we perceive are mental representations about sense-data and the respective mental representations form the reality what we experience.[3]

Generally, there is a recognized difficulty in defining what is real. This lies with the theoretical terms - terms which are non-observable, as well the as with the language we use to describe them, which has no direct observational reference. Literature recognizes two alternate responses: the first one denies the separation between theoretical and

[1, 2, 3]Ryan et al. 2002

the second one accepts the distinction between theoretical and observational terms. However, it goes further arguing that the theoretical terms have no real observational meaning. The theoretical terms are seen as analytical constructions of observational terms and their relevance is in helping to compose observational implications and predictions. The latter one is known as instrumentalism.[1]

Norreklit et al.[2] argue that insufficient understanding of reality is the main inhibitor of creating valid knowledge and consequently about turning knowledge into action. As a response they establish a concept of reality as an integrated set of conditions capable of creating such understanding about the reality which tackles the knowing-doing gap. They distinguish between reality and the actual world and define reality as "…relation between the actor – whether a person or even an organization – and the world…thus the relation has to be constructed and the relation might be faulty." In addition, they present four dimensions, concepts for the valid construct of reality: facts, logic, values and communication. Each of these is covered next.

The concept of *facts* is about the relation between the actor and the world. Facts are recognized by an actor; they are based on a source and exist independently of the actor. Physical facts exist even without recognition by an actor. Would facts be the only component of the reality, validity would be reduced to the recognition of facts. Consequently, facts are seen as a necessary but not as a sufficient condition of reality. Facts do not constitute reality alone.[3]

The concept of possibilities is necessary to define the concept of *logic*. If there are no possibilities, a human being or an organization cannot be seen to have a future. Possibilities are constructed using logical operations where the actual construction is based on previous learning and happens largely automatically. Elementary logic negates known facts, composes the future possibilities and analyzes the outcomes. The central social task of leaders and managers in organizations is described as guiding of the construction of possibilities. Logic, as a dimension, refers to the systematic argumentation with concepts already given and to activities, which are used to create new concepts of possibilities or alternatives. As with facts, logic is a necessary but not a

[1]Ryan et al. 2002
[2, 3, 4]Norreklit et al. 2006

sufficient condition of reality alone.[1]

Values provide reasons to choose between possibilities and act upon them. Values are the actors' motivating force. They translate will and energy into action. If an actor has no values, he cannot decide about the necessary course of action and consequently will not be able to do anything. Companies and the managers within them need to take note that as employees make their values visible to them, respect of those individual values can help to make the employees more productive. If the company's values differ materially from those of the employee, the employee may not be of much value to the company. It is important to note that facts and logic have no value as standalone concepts for the actor– connecting facts and logic through values drives the value. As with facts and logic, values are a necessary but not a sufficient condition of reality alone.[2]

Combining facts and logic through values will cause actors to act. *Communication* transforms the individual level of reality into a intersubjective, socially organized reality. Communication is the vehicle enabling cooperation and grants managers the access to the subjective values and reasoning of employees. It drives the objectification of values and allows a social logic to direct which management control methods could be used in a company. As with facts, logic and values, communication is a necessary but not a sufficient condition of reality alone.[3]

Norreklit et al.[4] summarize reality into a conceptual framework integrating facts, logic, values and communication. They argue that the validity of any conceptual framework has to be examined whether or not it integrates the four dimensions of reality. Only if it does so adequately, is it valid. If it does not, it is only an abstraction. Norreklit et al.[5] also interestingly present power as directly linked to reality: "Power is the ability to make things happen…Any entity to which power can be attributed has power only because of the degree of integration it represents. Power is not something over and above that, which controls reality. Power is an expression of reality."

Norreklit et al.[6] argue that for a measurement system to be valid, it has to fulfill the

[1, 2, 3, 4,5] Norreklit et al. 2006
[6] Norreklit et al. 2007 in Neely 2007

criterias of internal and external coherence. Internal coherence is composed of operational coherence and theoretical coherence[1]. Operational coherence lies within the defined measurement rules, standards and concepts. The measurement units are expressed numerically and the description and application of a measurement operation is discovered via the number of units for a given object[2]. The theoretical coherence stands for operational concepts which are theoretically defined by means of other concepts[3]. External coherence is composed of company coherence and institutional coherence; company coherence stands for the coherence of the relation of an operating conceptual system to another operating conceptual system, i.e. that a measurement system needs to interact coherently within the company it's used in as well as with the society[4]. Institutional coherence means that the system is coherent with institutional phenomena such as laws, money and accounting[5].

Norreklit et al.[6] also presents a framework (Figure 5) about the ontological and epistemological nature of the data of different financial and management accounting phenomena. It displays the different characteristics of the data and ties its nature and quality into a concrete premise.

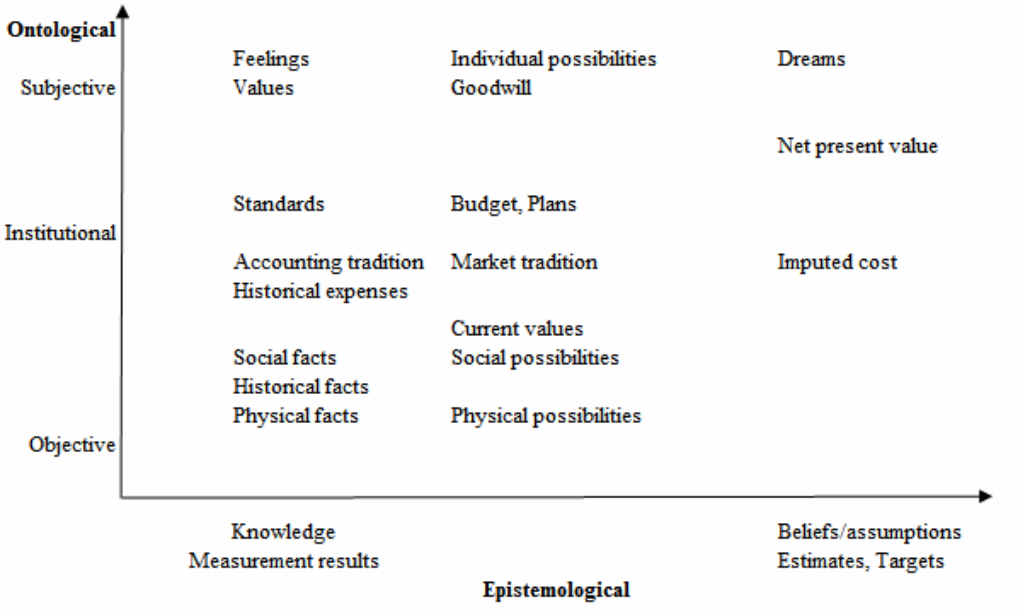

Figure 5 The ontological and epistemological nature of data

[1, 3, 4, 5]Norreklit et al. in Neely 2007
[2]Sterling 1970 in Norreklit et al. 2007 in Neely 2007

2.4 Measures of performance

Individual measures of performance have been subject to a lot of academic research. A wide range of criteria has been developed by academics as indicators of good performance measures (and performance measurement systems)[1]: measures need to relate directly to the organizations' mission and objectives, reflect the external competitive environment, the customer requirements and the internal objectives. In addition, they have a direct link in ensuring strategies, actions and measures are consistent[2]. This section proceeds as follows. First, different disciplinary approaches for designing performance measures are covered. Second, different dimensions of performance measures are reviewed. Third, the limitations of traditional performance measures and a comparison to non-traditional performance measures are covered. Last, the efficiency and effectiveness aspects of performance measures will be reviewed.

Measures of performance can be designed based in several different methodologies. *The engineering approach* relates output to input in each stage of the value chain and measures the input/output ratio. *The systems approach* sets targets for each unit of work or individual in an organization and measures the attainment of these targets. *The management accounting approach* measures the attainment of financial targets on a defined business unit level and develops the measures accordingly. *The statistical approach* works together with the engineering approach. It seeks to empirically test the correlations of the input/output relationships. *The consumer marketing approach* measures customer satisfaction. T*he conformance to specifications'* approach is a quality management approach which uses a list of different variables of a product or service in combination with its delivery system.[3]

Performance measurement systems consist of various measures using a variety of dimensions of the measures.. Neely et al.[4] highlight the significance of quality, time, cost and flexibility dimensions (Table 2).

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[1]Kennerley and Neely 2002
[2]Please see Globerson 1985, Wisner and Fawcet 1991, Maskell 1989, Kaplan and Norton 1993, Lynch and Cross 1991 and Dixon et al. in Neely et al. 2005
[3]Waggoner et al. 1999
[4]Neely et al. 2005

Quality	**Time**
Performance	Manufacturing lead time
Features	Rate of production introduction
Reliability	Deliver lead time
Conformance	Due-date performance
Technical durability	Frequency of delivery
Serviceability	
Aesthetics	
Perceived quality	
Humanity	
Value	

Flexibility	**Cost**
Material quality	Manufacturing cost
Output quality	Value added
New product	Selling price
Modify product	Running cost
Deliverability	Service cost
Volume	
Mix	
Resource mix	

Table 2 Quality, time, cost and flexibility dimensions of measures[1]

Quality has usually been understood as conformance to a product or service specification[2]. Feigenbaum[3] has been recognized as the first one to propose the total cost of quality as a function of prevention, appraisal and failure costs. Campanella and Corcoran[4] define three types of cost:

i. Prevention cost are those costs expended in an effort to prevent discrepancies

ii. Appraisal costs are those costs expended in the evaluation of product quality

iii. Failure costs are those costs expended as a result of discrepancies.

[1, 2]Neely et al. 2005
[3]Feigenbaum 1961 in Neely at al. 2005
[4]Campanella and Corcoran in Neely et al. 2005

The optimal level of cost of quality is tied to organisational conditions. For a given level of production and effectiveness, there exists an optimal level of quality and the cost of quality is due to the organization either over or underperforming against that optimum.[1]

Time is a source of competitive advantage and a key measure in manufacturing performance[2]. House and Price[3] and Fooks[4] report on the use of time-cost profiles, which display the sales, profit and investment as a function of time, as means to capture the significance of time as measure. Galloway's and Waldron's[5] time based costing system known as throughput accounting is based on the three assumptions:

i. Manufacturing units are an integrated whole, whose operating costs in the short term are largely predetermined.
ii. For all business units, profit is a function of the time taken to respond to the needs of the market
iii. It is the rate at which a product contributes money that determines its relative product profitability.

Cost is the most traditional measure of performance. Kaplan[6] has reviewed Garner's[7] work and states that most of the modern cost accounting theories were developed already by 1925. Traditional accounting, purely measuring cost has received substantial criticism and it's been suggested that an intentional disconnect between external financial reporting and information systems which are used for strategic decision making would be beneficial[8]. Productivity is a derivative of cost, but still categorized as cost based is a measure which is defined as the ratio of output to total input[9]. Ruch[10] provides five categories to improve productivity:

[1, 8]Neely et al. 2005
[2]Stalk 1988 and Drucker 1990, in Neely et al. 2005
[3]House and Price 1991 in Neely et al. 2005
[4]Fooks 1992 in Neely et al. 2005
[5]Galloway and Waldron 1988a, b, 1989a, b in Neely et al. 2005
[6]Kaplan 1984 in Neely et al. 2005
[7]Garner 1954 in Neely et al. 2005
[9]Burgess 1990 in Neely et al. 2005
[10]Ruch 1982 in Neely et al. 2005

i. Increasing the level of output faster than that of the input (managed growth)
ii. Producing more output with the same level of input (working smarter)
iii. Producing more output with a reduced level of input (the ideal)
iv. Maintaining the level of output while reducing the input (greater efficiency)
v. Decreasing the level of output but decreasing the level of input more.

Flexibility is a measure which has multiple definitions. Slack[1] has originally identified range, cost and time as dimensions of flexibility and later modified the definition to including only range and response. He defines range as how far the manufacturing systems can change and response as how rapidly and cheaply it can change. The view from Cox[2] which defines flexibility as a measure of both efficiency and how fast the production systems can be changed supports the definition of Slack's. On the other hand, Gerwin[3] has recognised a lack of operational measures of flexibility.

Fitzgerald[4] et al. recognize the variety of dimensions organizations compete in. In response to this variety,, they suggest a feedforward/feedback control model which is based on six different performance dimensions (Table 3). Two of the six represent results (consequences) and four of them represent determinants (drivers) of the results. Fitzgerald et al. emphasize that the dimensions are in constant interaction with each other and that trade-offs between the dimensions are necessary during the strategy formation process to ensure the plans will be balanced going forward.

Ghalayni and Noble[5] argue there are key limitations inherent to the traditional performance measures. Traditional measures are based on historical management accounting systems that were developed during times when direct labour cost was a significant part of the total costs. They are lagging metrics and lack the relevance to corporate strategy and relevance to practise. Traditional measures can also be seen as

[1]Slack 1983, 1987 in Neely et al. 2005
[2]Cox 1989 in Neely et al. 2005
[3]Gerwin 1987 in Neely et al. 2005
[4]Fitzgerald et al. 1991
[5]Ghalayini and Noble 1996

Dimension of performance	Types of measure
Results	
Financial Performance	
	Profitability Liquidity Capital structure Market ratios
Competitiveness	
	Relative market share and position Sales growth Measures of the customer base
Determinants	
Resource utilization	
	Productivity Efficiency
Quality of service	
	Overall service indicators: Reliability Responsiveness Aeasthetics/appearance Cleanliness/tidiness Comfort Friendliness Communication Courtesy Competence Access Availability Security
Innovation	
	Performance of the innovation process Performance of the individual innovations
Flexibility	
	Specification flexibility Volume flexibility Delivery speed flexibility

Table 3 Business performance dimensions[1]

[1]Fitzgerald et al. 1991

expensive, inflexible and not allowing continuous improvement and customer interlock activities. Table 4 compares the traditional measures with non-traditional.

Traditional performance measures	**Non-traditional performance measures**
Based on outdated traditional accounting	Based on company strategy
Mainly financial measures	Primarily non-financial measures
Intended for middle and high managers	Intended for all employees
Lagging metrics (weekly or monthly)	On-time metrics (hourly or daily)
Difficult, confusing and misleading	Simple, accurate and easy to understand
Lead to employee frustration	Lead to employee satisfaction
Neglected on the shop floor	Frequently used on the shop floor
Have a fixed format	Have no fixed format (depends on the needs)
Do not vary between locations	Vary between locations
Do not change over time	Change over time as the needs change
Intended mainly for monitoring Performance	Intended to improve performance
Not applicable for JIT, TQM, CIM, FMS, RPR, OPT	Applicable
Hinders continuous improvement	Help in achieving continuous improvement

Table 4 A comparison between traditional and non-traditional performance measures[1]

Neely et al.[2] have researched the literature and suggest a Performance measurement record sheet as a response to satisfying the criterias set out in the literature to ensure the *effectiveness and efficiency of a measure*[3]. The Performance measurement record sheet documents all the relevant aspects of a measure which is used in an organization: it asks for the title, purpose, object the measure relates to, target, formula, frequency of measurement, frequency of review, who is responsible for the actual act of measuring, sources of data, who owns the measure, who acts on the data, what do the they do based on the data and any possible notes and comments.

[1]Ghalayini and Noble 1996
[2]Neely et al. 1997
[3]Please see a complete list of criterias to ensure the effectiveness and efficiency of a measure as Attachment 1.

Based on literature, Kennerley and Neely[3] present also a number of tests to ensure a measure is relevant (Table 5):

The truth test	Is the measure measuring what it's meant to measure?
The focus test	Is the measure only measuring what it's meant to measure?
The consistency test	Is the measure consistent whenever or whoever measures?
The access test	Can the data be readily communicated and easily understood?
The clarity test	Is any ambiguity possible in interpretation of the results?
The so what test	Can and will the data be acted upon?
The timeliness test	Can the data be analyse soon enough so that action can be taken?
The cost test	Is it worth the cost of collecting and analysing the data?
The gaiming test	Does the measure encourage any undesirable behaviours?

Table 5 Tests of relevance of individual performance measures

[1]Kennerley and Neely 2003

3 PERFORMANCE MEASUREMENT SYSTEMS AND CONTINGENCY THEORY

3.1 Introduction

The core of the contingency theory is that organizational effectiveness and performance results from characteristics of the organization, such as its structure, fitting to contingencies which reflect the situation of the organization. Consequently, fit is something that organizations constantly seek to attain and they adapt over time to fit their changing contingencies to maintain performance. At the abstract level, the contingency theory means that the effect of one variable on another variable depends on some third variable. In terms of organizations, a contingency is any such variable which moderates the effect of an organizational characteristic on organizational performance.[1]

The contingencies include the environment, organizational size and organizational strategy[2]. Contingency theory is composed of three elements which together form a core paradigm:

i. There is an association between contingency and the organizational structure
ii. Contingency determines the organizational structure, as an organization which changes its contingency, in effect changes its structure
iii. There exists a fit of some level of the organizational structural variable to each level of contingency, which leads to higher performance, whereas a misfit leads to lower performance.[3]

The third point is the single most important element. It displays the fit-performance relationship as well as it provides a theoretical explanation for the first two: an organization which changes its contingencies or their levels, is assumed to have been in fit before the change and moves into a state of misfit which causes its performance to deteriorate. Then, the organization changes its organizational structure to fit the new levels of the contingency variable to regain fit and performance.

[1, 3] Donaldson 2000
[2] Please see e.g. Burns and Stalker 1961, Child 1975 and Chandler, in Donaldson 2000

into a change in structure and consequently, contingency determines structure.[1]

The contingency theory of management accounting says that there is not one valid management accounting system for all organizations, but that the choice and the consequent characteristics of a valid system will depend on the circumstances of the specific organization. The central "circumstance", a contingency, is the strategy and the consequent specific objectives that the organization decides to pursue.[2]

Before entering the theoretical considerations between performance measurement systems and contingency theory, it is important to define *performance measurement system* (PMS) as it is meant in the context of this research. Otley[3] defines management control systems (MCS) as providing information which is intended to be of value for managers performing their job and assisting organizations in developing viable patterns of behaviour. He points first back to the traditional framework of Anthony[4] as the starting position but refers then to the two known examples of deliberate neglect of the framework, namely operational control and strategic planning and argues it is now the time to focus on the neglected areas and link the operational control and strategic planning into the framework. Consequently, Otley sees the formal performance measurement system as a major mechanism to make explicit the means-to-an-end relationships that the organization has developed.[5] On the other hand, Chenhall[6] points out that the meaning of a management control system has evolved since its introduction: "The definition of MCS has evolved over the years from one focusing on the provision of more formal, financially quantifiable information to assist in managerial decision making to one that embraces a much broader scope of information. This includes external information related to markets, customers, competitors, non-financial information related to production process, predictive information and a broad array of decision support mechanisms, and informal personal and social controls." Looking into the definitions that Otley[1] and Chenhall[2] provide, it can be argued that they both mean the same thing but Otley[3] refers to a performance measurement system while Chenhall[4] refers to an evolved management control system. This research follows the direct quote

[1]Donaldson 2000
[2, 3, 5]Otley 1999
[4]Anthony 1965
[6]Chenhall 2003

from Chenhall,[1] and agrees on the definition of an MCS according to the one Chenhall has provided.

It is also noteworthy to point out that this research chooses strategy, national culture, organizational structure and size as contingencies to be analyzed. Strategy has been noted as the most important contingency and as having the biggest effect on the how the valid performance measurement system should look. The impact of national culture can be argued to have grown over the past two decades driven by economic globalization whereas structure and size remain fundamental aspects of any organization. The environment has also been generally referred to as a significant contingent variable. Its main implication for organizations is considered to be the uncertainty it creates[3]. This research focuses on the concept of uncertainty in section 4.2.

3.2 Strategy

Strategy related contingency-based research predicts that certain types of performance measurement systems will be more suitable to a particular strategy than some others[4] and literature suggests directly that performance measurement systems need to be explicitly designed to support the strategy of the business to lead to and support competitive advantage[5]. Chenhall[6] points that strategy is a different contingent variable than the others. He argues it is not itself an element of the context – as the other contingent variables – but the means through which managers can affect the organization's future.

Research around strategy as contingent variable is challenged by the fact that more and more organizations need to compete on low cost, high quality and on time, reliable delivery. Getting one right is not enough in today's ultra competitive marketplace. The role of strategy is dynamic while managers continuously look for ways to integrate all the internal and external factors in an optimum way. The relationship between performance measurement systems and strategy in the optimization task is two-dimensional: first, it provides concrete data to help managers in formulating strategy

[1, 3, 6]Chenhall 2003
[2]Otley 1999
[4]Please see e.g. Langfield-Smith 1997, Miles and Snow 1978 in Chenhall 2003 and Chenhall 2003
[5]Langfield-Smith 1997

and second, after the strategy is implemented, it can provide managers feedback and enable learning about where and how execution of the strategy is going.[1]

Simons[2] provides a process interaction view into the relationship between strategy and PMS and argues that there are four dimensions linking PMS and strategy:

i. A belief system which communicates and reinforces basic values and missions
ii. Boundary systems which establish limits and rules
iii. Diagnostic controls which monitor the outcomes and take corrective actions when deviations incur
iv. Interactive controls which will allow top managers to involve themselves directly with the operations.

Chenhall[3] takes a more traditional approach. He finds several generic strategic taxonomies from the literature (entrepreneurial-conservative, prospecters-analyzers-defenders, build-hold-harvest and product differentiation-cost leadership) and provides a summary about the contingent relationships between the taxonomies and PMS:

i. Strategies characterized by conservatism, defender orientations and cost leadership are more associated with formal, traditional PMS focused on
ii. cost control, specific operating goals and budgets and rigid budget controls, than entrepreneurial, build and product strategies
iii. With regard to product differentiation, competitor focused strategies are associated with broad scope PMS for planning purposes, and customization strategies are associated with aggregated, integrated and timely PMS for operational decisions
iv. Entrepreneurial strategies are associated with both formal, traditional PMS and organic decision making and communications

[1, 3] Chenhall 2003
[2] Simons 1994 in Chenhall 2003

v. Strategies characterized by defender and harvest orientations and following cost leadership are associated with formal performance measurement systems including objective budget performance targets. In comparison, more prospector oriented strategies require informal, open PMS characterized by more subjective long term controls and interactive use of budgets focused on informal communications.

3.3 National culture

This significant research area in management accounting is focused on the notion that there could be a relationship between the national cultural variables and management control systems, which are referred to in the context of this research as the performance measurement systems, and performance[1]. Research in the area has found accumulating evidence that employees in different cultures display different reactions to management controls and practises[2]. This results in the possibility that management practises and the related performance measurement systems which function well in one country can be ineffective or even dysfunctional in another[3].

This research follows Hofstede[4] in defining culture: "Culture is the collective programming of the mind which distinguishes one group or category of people from another and a construct which is not directly accessible for observation but inferable from verbal statements and other behaviours and useful in predicting still other observable and measurable verbal and nonverbal behaviour". Hofstede[5] is also the developer of the most widely used characteristics of culture when it comes to researching culture and management control systems; namely power distance, individualism, masculinity/femininity and uncertainty avoidance. Power distance is a measure of the inequality among the people; large power distance means that the

[1]Please see e.g. Awasthi et al. 1998, Chow et al. 1997, Hofstede 1993 and Tsui 2001 for specifics and Chenhall 2003 and Harrison et al. 1999 for a general review about the research area
[2]Please see Adler 1986, Hofstede 1980, 1991, Kreder and Zellen 1988 and Vance et al. 1992 in Chow et al. 1997
[3]Tsui 2001
[4]Hofstede 1993
[5]Hofstede 1980

respective population is highly unequal while short power distance represents equality. Individualism refers to the extent which people in a country like to act as individuals. Masculinity represents the degree of tough values, such as assertiveness, performance, success and competition. Uncertainty avoidance is the measure for people preferring structured approaches over unstructured ones. Hofstede and Bond[1] recognized also the existence of long term orientation vs. short term orientation which is the measure of how values concerning long term versus short term are valued. Hofstede[2] reports the cultural profiles of ten countries (Table 6) and concludes that generally US culture displays as below the average on power distance and uncertainty avoidance, highly individualistic, and fairly masculine and short-term oriented while the German culture is shown as not as willing to tolerate so much uncertainty and not so individual. French culture display greater power distance and uncertainty avoidance while Dutch culture resembles the US on the first three dimensions.

PD = Power Distance; ID = Individualism; MA = Masculinity; UA = Uncertainty Avoidance; LT = Long Term Orientation)
H = top third, M = medium third, L = bottom third (among 53 countries and regions for the first four dimensions; among 23 countries for the fifth)

	PD	ID	MA	UA	LT
USA	40 L	91 H	62 H	46 L	29 L
Germany	35 L	67 H	66 H	65 M	31 M
Japan	54 M	46 M	95 H	92 H	80 H
France	68 H	71 H	43 M	86 H	30*L
Netherlands	38 L	80 H	14 L	53 M	44 M
Hong Kong	68 H	25 L	57 H	29 L	96 H
Indonesia	78 H	14 L	46 M	48 L	25*L
West Africa	77 H	20 L	46 M	54 M	16 L
Russia	95*H	50*M	40*L	90*H	10*L
China	80*H	20*L	50*M	60*M	118 H

* estimated

Table 6 Culture dimension scores for 10 countries[3]

Harrison et al.[4] argue that while there is some evidence about convergence in terms of the effect of culture on PMS characteristics, there are also substantive disparities among the findings. Four methodological weaknesses found in the literature are reported as a response:

i. Failure to consider the totality of the cultural domain in theoretical exposition

[1]Hofstede and Bond 1988 in Harrison et al. 1999
[2, 3]Hofstede 1993
[4]Harrison et al. 1999

ii. A tendency to not consider explicitly the differential intensity of cultural norms and values across nations

iii. A tendency to treat culture simplistically both in the form of its representation as a limited set of aggregate dimensions, and in the assumption of a uniformity and singularity of those dimensions

iv. An excessive reliance on the value of dimensional conceptualization of culture has produced a highly restricted conception and focus on culture and placed critical limits on the extent of understanding derived from the research to date.

Harrison et al.[1] consider the research about the effects of the characteristics of the cross-cultural environments for performance measurement systems to be in its infancy and suggest that the way culture is considered in the research would need to be more fully addressed.

3.4 Organizational structure

Organizational structure refers to the formal definition of roles for organizational members to ensure that the tasks are assigned in the organization and will be performed. The respective structural arrangements have an impact to the efficiency and effectiveness of the organization. Differentiation and integration can be seen as the two extremes that display how an organization is structured; differentiation refers to the extent on how managers can be seen to act as internal entrepreneurs and integration is the measure of the extent to which profit centres can be seen to act in a manner which is consistent with the organizational goals.[2]

Chenhall[3] concludes about PMS and organizational structure:

i. Large organizations with sophisticated technologies, high diversity and more decentralized structures are associated with more formal, traditional PMS (e.g. budgets, formal communications)

[1]Harrison et al. 1999
[2,3]Chenhall 2003

ii. Research and development departments compared to marketing departments, which face higher levels of uncertainty, are associated with participative budgeting; and marketing compared to production departments, which face higher levels of external environmental uncertainty, are associated with more open, informal PMS.

iii. Participative budgeting is associated more with the structural characteristics or functional differentiation of research and development departments compared to marketing departments as well as with leadership styles characterized by a consideration compared to initiating style

iv. Decentralization is associated with PMS characteristics of aggregation and integration

v. Team based structures are associated with participation and comprehensive performance measures used for compensation

vi. Organic organizational structures are associated with the perception that future oriented PMS are more useful, and with the effective implementation of activity analysis and activity cost analysis.

3.5 Size

There are several ways to measure size, e.g. profits, sales volume, assets, share valuation and number of employees. It's noted that the use of financial measures can make the comparisons difficult as different accounting valuation methods are used. Consequently, the majority of contingency based research on size has adopted the approach of measuring size through the number employees.[1]

When organizations grow, the volume of information grows exponentially and managers need to be able to cope with this influx of information. Often growth leads to management establishing new rules, documentation, creating specialization of roles and functions, building extended hierarchies or forcing a greater decentralization down the hierarchical structures to enable more control.[2]

[1, 2]Chenhall 2003

Burns and Waterhouse have[1] found two kinds of controls associated with size:

i. Administrative control and large firms; control is composed of more sophisticated technologies, standard operating procedures as well as of high levels of specialists and work related rules. Budgets were perceived as limiting innovation and flexibility.
ii. Interpersonal control and small firms; control is composed of centralized decision making, individuals saw themselves having more to do with the budget related matter and were satisfied with their manager-relationship.

Chenhall[2] concludes about performance measurement systems and size:

i. Large organizations are associated with more diverse operations, formalized procedures and specialization of functions
ii. Large organizations are associated with more divisionalized organizational structures
iii. Large size is associated with an emphasis on and participation in budgeting and sophisticated controls.

[1]Bruns and Waterhouse 1975 in Chenhall 2003
[2]Chenhall 2003

4 DYNAMISM, UNCERTAINTY, PREDICTION AND PERFORMANCE MEASUREMENT

4.1 Dynamism – factors affecting the development of performance measurement systems

Measurement systems evolve over time. However, most of the research has focused on looking at this area in a static context and the dynamism within these systems has been generally overlooked[1]. Neely[2] argues that the premise for recognizing the dynamics of performance measurement systems lies in the fact that the measures and the measurement systems reflect the context where they are used. Focus has been given on solving issues which matter today rather than focusing on what will matter tomorrow as well. A lot of time has been spent on redesigning the measurement systems but little evidence exists that organizations will be managing their measurement systems when the context changes[3].

In organizations not managing their measurement systems in an evolutionary manner, too many measures are in place and the organizations are drowning in data. As a consequence, there is imminent risk that the measurement systems will become or are obsolete and non relevant. PMS lose their validity over time[4]. In the context of dynamic performance measurement, Meyer and Gupta[5] have identified the existence of a performance paradox, which describes a weak correlation between the performance indicators and performance itself. It's argued that this is driven by the performance measures running down over time. Measures lose their significance in measuring performance and over time cannot distinguish between good and bad results. Eventually, the correlation of reported and actual performance deteriorates.

Meyer and Gupta[6] argue that the weakening correlation is due to four different forces:

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[1]Kennerley and Neely 2002
[2]Neely 1999
[3, 4]Kennerley and Neely 2003
[5, 6]Meyer and Gupta 1994

i. positive learning
ii. perverse learning
iii. selection
iv. suppression

Positive learning refers to a process where measures lose their sensitivity to reflecting poor performance. The Organization appears to be performing so well against the measure that only good results can be reported. *Perverse learning* captures circumstances where organizations have learned what is and what is not measured. And consequently the respective knowledge can be used to manipulate the outcomes. Performance against what is measured goes up but actual performance deteriorates. *Selection* refers to a process where the selection of good performers reduces the variance of the measured result. Bad performers are ignored. The measure loses it relevance as the results represent only the outcomes of good performers. *Suppression* means directly ignoring bad results.[1]

Waggoner et al.[2] were among the first who started to focus on the evolutionary aspects of performance measurement systems. They noted that the key to understanding the implicit and explicit developments in the area is the identification of the forces driving the evolution. Their synthesis over different academic publications from several disciplines, such as operations management, social psychology, strategic management, management accounting and organizational behaviour and economics produced an identification of four specific forces affecting the evolution of performance measurement systems.

i. Internal forces, such as power relationships and dominant coalition interest
ii. External influences, such as legislation and marker volatility
iii. Process issues, such as manner of implementation and management of political processes
iv. Transformational issues, such as degree of top-level support and risk of gain or loss from change

[1]Meyer and Gupta 1994
[2]Waggoner et al. 1999

Underlying the four specific forces, institutional theory, organizational ecology, strategic choice, evolutionary economics and organizational learning are highlighted by Waggoner et al.[1] as important sources of information to help in the understanding of the organizational processes and practices within the context of performance measurement system evolution. He proposes three major areas of focus: entities (organizations), processes (e.g. institutionalisation) and events (e.g. transformation and change). However, Pettigrew and Whipp[2] consider that as the management decision making is a political process, no matter what, the evolution of the performance measurement system will be disturbed by organizational politics.

Bititci et al.[3] have advanced the research about the dynamics of performance measurement systems. They have identified the key characteristics of a dynamic system:

i. sensitive to changes in the external and internal environment of an organization
ii. capable of reviewing and reprioritising internal objectives when the changes in the external and/or internal context are significant enough
iii. capable of deploying the changes to internal objectives and priorities to critical parts of organization, thus ensuring alignment at all times
iv. capable of ensuring that gains achieved through improvement programmes are maintained

As a result of the key characteristics, Bititci at al.[4] have defined the key functions and the key tasks of a dynamic system:

i. an external monitoring system
ii. an internal monitoring system
iii. a review system
iv. an internal deployment system

The external monitoring system should continuously monitor developments and changes in the external environment while the internal monitoring system should

[1]Waggoner et al. 1999
[2]Pettigrew & Whip 1991
[3,4]Bititci et al. 2000

monitor developments and changes in the internal environment. Both monitoring systems can raise warning and action signals when certain performance limits and thresholds are reached. The role of the review system is to use information from the external and internal monitors as well the objectives and priorities set by the higher level systems and consequently to rule on and adjust internal objectives and priorities. The deployment system's role is to deploy the updated objectives and priorities to organization. Bititci et al.[1] also point out that the need for change in corporations is not always driven by the top management but more often it's a result of an external or internal change which happens on a business unit or on a business process level.

Based on literature review of the factors affecting the evolution of performance measurement systems, Kennerley and Neely[2] have drawn conclusions illustrated in Figure 6. The drivers of change are seen as factors which cause the change to be necessary and the barriers to change are shown as factors which must be overcome if change is to be effective.

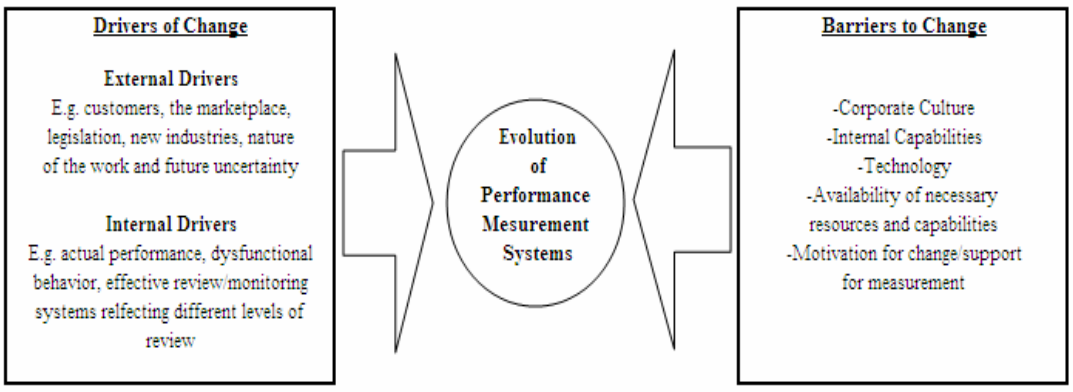

Figure 6 Summary of factors affecting evolution of performance measurement systems[3]

Kennerley and Neely[4] have further refined the barriers to change into four categories instead of the five presented in Figure 6: process, people, culture and systems. There has to exist a clearly defined and explicit process for reviewing, modifying and deploying measures for an organization to be able to overcome the first barrier of change. That barrier exists if the organization does not have the right people in place.

[1]Bititci et al. 2000
[2, 3, 4]Kennerley and Neely 2002

This includes the respective people are available when necessary and have the right skills for the task. The people need to be able to reflect on their work as well as to be able to modify and deploy measures when necessary. The right infrastructure will need to be in place. This includes the availability of flexible systems which need to be able to collect, analyse and report the appropriate data. Last, culture of meaningful measurements has to exist.. People will need to appreciate the produced information, use it to improve their knowledge, understand the importance of maintaining relevant data and appropriate measures as well as believe and support the consequent value of measurement.

It is in the context of drivers of change and barriers of change that Kennerley and Neely[1] point out that a performance measurement system consists of three components:

i. Individual measures that quantify the efficiency and effectiveness of actions
ii. A set of measures that combine to assess the performance of an organization as a whole
iii. A supporting infrastructure that enables data to be acquired, collated, sorted, analysed, interpreted and disseminated.[2]

Kennerley and Neely[3] recognize that both the existence of the three above components of a performance measurement system and the active use of the PMS are required to provide a proper starting place for evolution of the PMS. Typically an evolution starts with either an internal or external trigger. It's also recognized that there are three stages in the evolution of a measurement system after the pre-requisites are fulfilled: reflect, modify and deploy. Reflect refers to the reflection on the existing performance measurement system to identify where it is no longer appropriate and where enhancements are needed. Modify refers to the modification of a performance measurement system to ensure alignment to the organization's new circumstances. Deploy refers to the deployment of the modified performance measurement system so that it can be used to manage the performance of an organization. Reflection, modification and deployment –processes are the premise of an evolutionary, dynamic performance measurement system.

[1, 3] Kennerley and Neely 2002
[2] Neely, A., Gregory, M. and Platts, K. 2005

Kennerley and Neely[1] argue that at the point of implementation most performance measurement systems reflect the context and objectives of the organization. However, they most often leave two questions unanswered, leading into a situation where the implemented system is not dynamic and fails to manage any changes in the context or objectives of the organization:

i. Which factors affect (facilitate and inhibit) the way in which measurement systems change over time?
ii. How can organizations manage their measurement systems so that they continually remain relevant?

As a structured response to the two questions, Kennerley and Neely[2] present a framework of factors affecting the evolution of performance measurement systems (Figure 7) and suggest that the critical success factor of making the evolutionary process work properly is that each of the elements of the performance measurement system must be managed and reflected on separately in order to retain its significance for the organization.

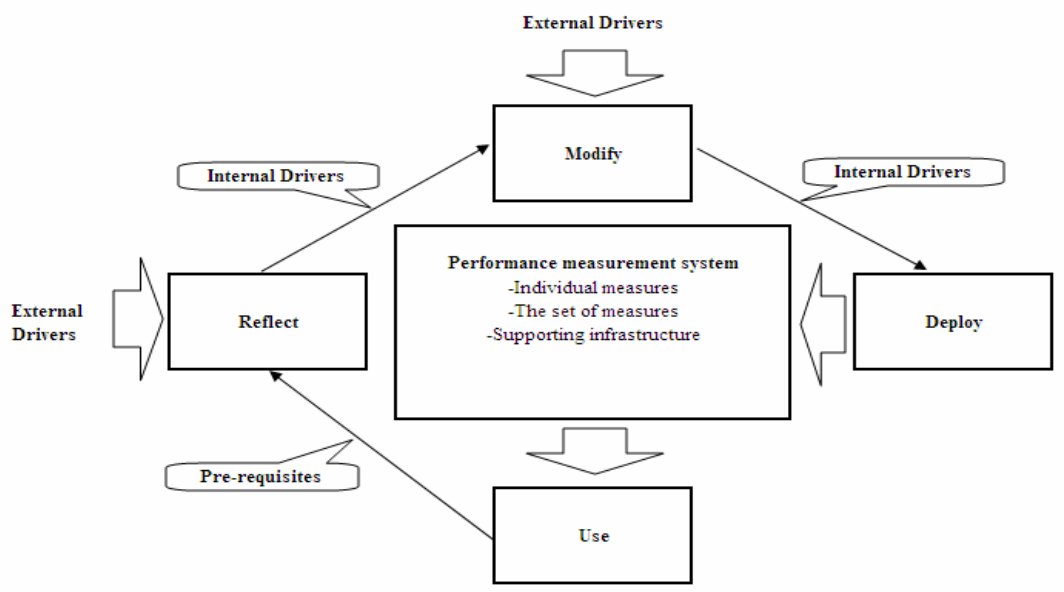

Figure 7 Framework of factors affecting the evolution of performance measurement systems[3]

[1]Kennerley and Neely 2003
[2, 3]Kennerley and Neely 2002

Reflection on the individual measures can be conducted e.g. according to the Performance measure record sheet[1]. Reflection on the set of performance measures is ment to identify whether right things are being measured and the purpose of the reflection should be to identify if the set of performance measures is a) balanced b) aligned to strategies, philosophies and incentive schemes and c) comprehensive and consistent. The reflection on the supporting infrastructure is meant to recognize whether there are processes and systems in place to effectively collect and process data.[2]

4.2 Uncertainty and performance measurement

Performance measurement and performance measurement systems are largely based on deterministic, linear, assumptions about the world – they are based on certainty as such[3]. The desire for certainty is from the belief that goal setting, documentation and the linkages of measures with one another are seen as the enablers of proper management[4]. As the world around us is constantly changing, the deterministic assumptions have been questioned[5]. As a response, we have seen the emergence of Chaos theory argues that the relationships in complex systems, such as in organizations, are non-linear and composed of several interconnections[6].

The premise of the deterministic assumptions, the Newtonian science, is based on physics and mathematics. It's grounded on a belief that everything can be predicted by reducing any interaction to its basic elements. Taylorism is an organizational theory which was formalised during the industrial age and is based on the principles of Newtonian science. Organizations are seen as machines according to the Taylorist view, which assumes that the organizations can be decomposed into such small pieces that the interconnections of the pieces can be understood and documented.[7]

When society faced the industrial era, the principles of Newtonian science led

[1]Neely et al. 1997
[2]Kennerley and Neely 2003
[3, 4,7]Palmer and Parker 2001
[5]Stumpf 1995 in Palmer and Parker 2001
[6]Tetenbaum 1998

organizations to define success through maintaining stability. If the stability was lost, the main responsibility of management was to lead the organization into regaining equilibrium. This premise of management was grounded in the focus on regularity, deterministic predictability and efficiency. The shift from industrial age to information age has fundamentally changed all the aspects of work: the employee, the workplace and the work itself. Organizations need to deal with new technology, impacts from the increasing speed of globalization, more and smarter competition, bigger and faster changes and the influx of complex paradoxes, which they have not experienced before.[1] These paradoxes have been documented by Tetenbaum[2] (Table 7).

Long-term and short term	Independence and interdependence
Plan and experiment	People and productivity
Revenue growth and cost containment	Empowerment and accountability
Lower costs and increased quality	People skills and technical skills
Centralize and decentralize	Conflict and consensus
Product and process	Compete and cooperate
Creativity and efficiency	Stability and change
Core competency and diversification	Incremental and quantum
Specialist and generalist	Predictability and unpredictability
Entrepreneur and team player	Simplicity and complexity
Lead and follow	Intention and chance
Manager and leader	Regularity and irregularity
Take charge and everyone's a leader	Order and disorder

Table 7 Paradoxes for leaders and organizations in the 21st century

Chaos theory is a response to managing the challenges of the information era. It says that the world is full of unintended consequences and counterintuitive outcomes. In such a world one cannot reduce the interactions into their basic elements, decompose the Taylorist machine, and consider the interconnections of the components to be linear. The word chaos should not be misinterpreted either. For scientists it stands for an orderly disorder, where things occur in irregular but similar forms.[3] The premise for the relevance of chaos theory to performance measurement and performance measurement systems is best built through an analysis of three post-deterministic discoveries: uncertainty, bounded instability and self-organization.[4]

Uncertainty has two properties at its core, sensitive dependence on the initial conditions

[1, 2, 3] Tetenbaum 1998
[4] Palmer and Parker 2001

and the impossibility of measurement without participation. The sensitive dependence on the initial conditions has been originally observed by Edward Lorenz in the area of weather forecasting where he discovered that the computer simulations beginning from the same starting conditions produced greatly different results. Hawking[1], Gleick[2] and Felder and Felder[3] report the same kind of findings where the same initial conditions do not lead to same measured results. The impossibility of measurement without participation has been reported also by Hawking[4], Gleick[5] and Felder and Felder[6]: the results of the measurement will always be affected by the measuring itself. Before, it had been considered that if one measures carefully and discreetly enough, the system being measured would not be affected at all. However, based on the findings from the research, this assumption has been abandoned by physical scientists.[7]

Bounded instability also finds its origin back to Edward Lorenz's computer simulation over weather patterns.[8] His research displayed that the simulated particles of a weather system behaved momentarily chaotically but that there existed a general non-linear pattern when the movement of particles were studied over time. This general non-linear pattern has been observed to have a format of a butterfly and it is known today as an attractor system, specifically the Lorenz's attractor[9]. This aggregate view of the non-linear particle movement is known as bounded instability[10].

Self organization is known as a sudden and unpredictable change, which can be triggered by a small or a large event, in a non-linear system and which is based on a process of destabilization, followed by reconfiguration[11]. It means that when a bounded system is interfered with, it will organize itself into a new state of bounded instability[12]. Gleick[13], Kauffman[14], Kelly[15] and Parker[16] note the important characteristics of change in a self-organizing system:

[1, 4]Hawking 1998 in Palmer and Parker 2001
[2, 5]Gleick 1992 in Palmer and Parker 2001
[3, 6]Felder and Felder 1998 in Palmer and Parker 2001
[7, 8,10, 11]Palmer and Parker 2001
[9]Ott 1983 in Palmer and Parker 2001
[12]Guastello 1995 in Palmer and Parker 2001
[13]Gleick 1988 in Palmer and Parker 2001
[14]Kauffman 1996 in Palmer and Parker 2001
[15]Kelly 1994 in Palmer and Parker 2001
[16]Parker 1998 in Palmer and Parker 2001

i. Reorganization triggered by either a significant change in the external environment or a minor variation at an individual level which is then amplified throughout the system.

ii. Failure of the existing system followed by reconfiguration to a new state where it is better able to deal with its environment.

The consequences of the Chaos theory and its underlying premises of uncertainty, bounded instability and self-organization have multiple effects for modern performance measurement and performance measurement systems. They suggest that at the individual level, serious mistakes can happen if deterministic assumptions are used when performance is measured. Chaos theory argues that the measurement needs to focus on the aggregate level, observing the organization specific attractor systems and leveraging them in order for it to be able to capture the non-linear order and the bounded instability of the measured system.[1]

4.3 Prediction and performance measurement

The link between the leading and lagging indicators is well recognized in performance measurement literature and the link and its causal nature has been under extensive research[2]. It is also recognized in the literature that even though the concept of prediction is often referred to, there does not exist that much research covering the aspect of how to actually predict the performance[3]. The robust predictive capability of current performance measurement systems has also been questioned.[4] From a theoretical perspective, Dr Walter Shewhart can be considered as one the pioneers in the area. His theory of prediction developed in the 1920s and 1930s is based on applying statistical methods to business processes. Shewhart's theory is argued to add value to the process of performance measurement by incorporating a process based predictive element into the process of measurement, which is not deterministic by nature.[5]

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[1]Palmer and Parker 2001
[2]Please see e.g. Neely et al. 2005
[3]Please see e.g. Unahabhokha et al. 2007 and Wilcox and Bourne 2003
[4,5]Wilcox and Bourne 2003

"A phenomenon will be said to be in control when, through the use of past experience, we can predict, at least within limits, how the phenomenon may be expected to vary in the future. Here it is understood that the prediction within limits means that we can state, at least approximately, the probability that the observed phenomenon will fall within given limits…The specific problem that concerns us at the present moment is the information of a scientific basis for prediction, taking into account the element of chance, where for the purpose of our discussion, any unknown cause of a phenomenon will be termed a chance cause."[1]

The quote from Shewhart illustrates the essence of his theory built around three components of knowledge: evidence, prediction and the degree of belief in the prediction. The process of prediction starts with data collection which will be used as evidence. Shewhart distinguishes between data collected in controlled setting and in an uncontrolled setting. The prediction is based on using history to understand the current and to predict the future. The actual prediction is based on control charts that Shewhart invented. The control charts provide a graphical view into the variation of the process as a function of time. Variation can de divided into chance and assignable causes where a chance cause is an indicator of natural variation in the process and an assignable cause is an indicator of an external influence, which has caused the process to vary outside the limits. Shewhart was clear that only in the absence of assignable causes, one is able to predict with high degree of certainty. His work provides another valuable point for predicting and managing the outcomes of different processes: there is no point in trying to interfere with those processes which only display chance causes as the consequent variation is deemed normal.[2]

Wilcox and Bourne[3] conclude that the key to prediction is to dynamically measure when the correlation between the defined cause and effect holds and when it breaks. Whereas Shwehart's control charts are the key enabler of being able to so – distinguishing between those processes which are in control and those which are not, facilitates the process of setting the performance targets in a correct manner.

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[1]Shewhart 1931
[2]Wilcox and Bourne 2003

Unahabhokha et al.[1] present an alternative approach for prediction. They apply a fuzzy expert system approach for developing predictive performance measurement systems. A fuzzy expert system is a way of using non-quantitative information rather than exact numbers as the basis for prediction. The fuzzy system is used in the modelling world to predict the outcomes of lagging variables based on leading variables serving as the key input for prediction. The predicted outcomes are compared with the targets inside the corrective mechanism.

A fuzzy expert based predictive performance measurement system is displayed in Figure 8. Its key components are an inference engine, a knowledge base, a membership function and an if-then rule. The *Inference engine* is a mechanism which combines information from the inputs with the already existing knowledge base and formulates a consequent predictive value.[2]

The Membership function stores information about the characteristics of each leading and lagging variable. The function maps the inputs into non-quantitative, i.e. linguistic variables. An example would be where the membership function of machine efficiency is defined as high, medium or low. The degree of observed efficiency is denoted with a membership value between 0 and 1 and then the numeric values are mapped against the linguistic representations of high, medium and low respectively. Figure 9 displays the membership functions as graphical illustration. [3]

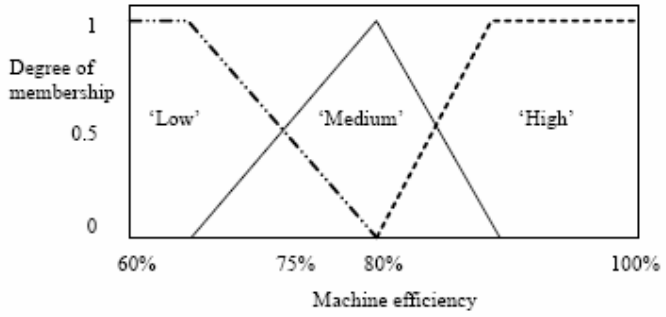

Figure 9 Membership functions of machine efficiency[4]

[1, 2, 3, 4]Unahabhokha et al. 2007

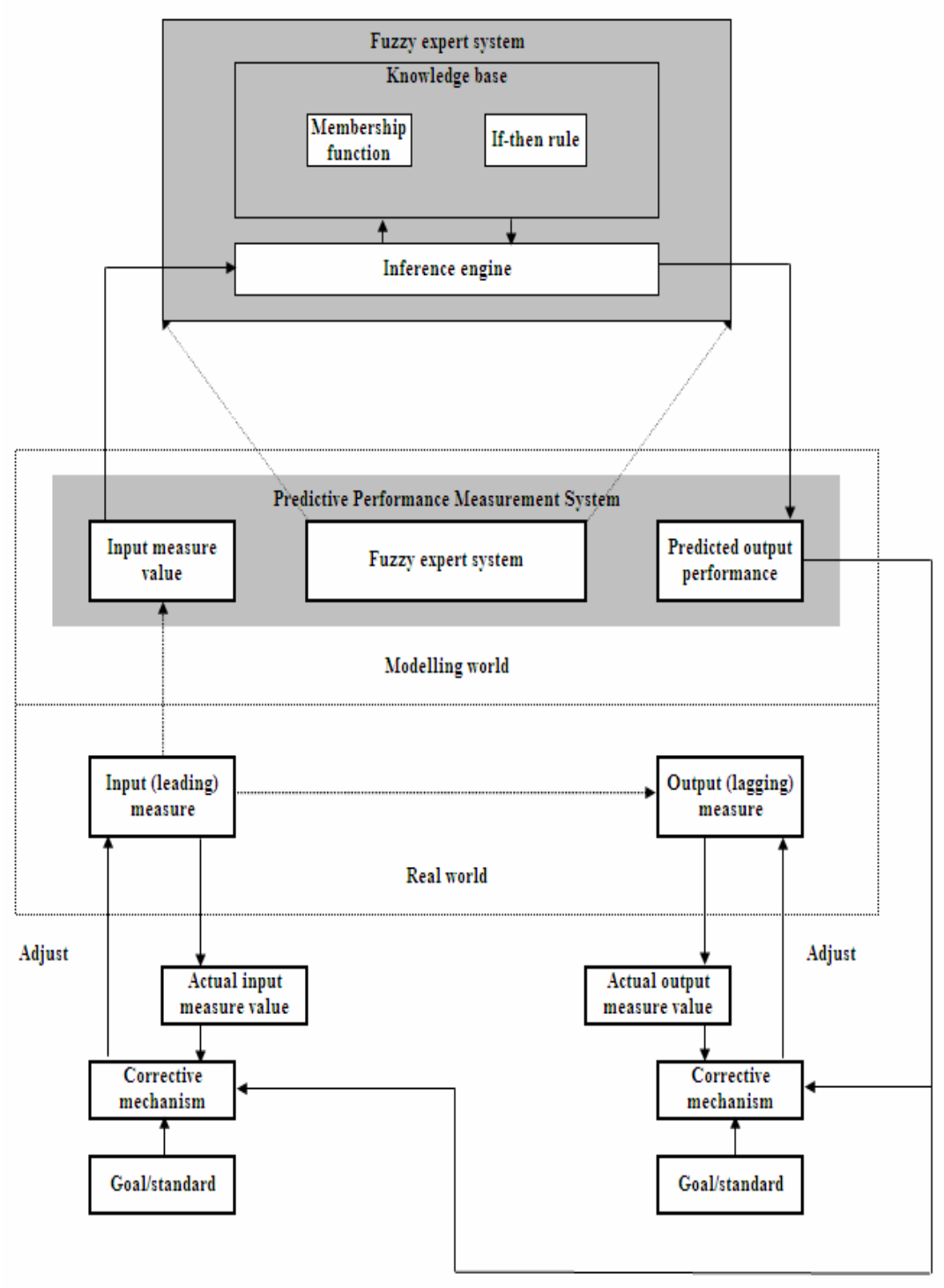

Figure 8 A fuzzy expert based predictive performance measurement system[1]

[1]Unahabhokha et al. 2007

If-then rules define the relationships between the predictive, leading variables and the output variables. The rules have been quoted as the brains of the fuzzy expert system in the literature, which define the conditional statements. As a fuzzy expert system is operated based in imprecise information about the world, the if-then rules are composed in the knowledge base of the system as linguistic values, not as exact numbers. An example of an if-then rule would be: "if x is A the y is B [x is a leading measure (antecedent) and y is a lagging measure (consequence) where A and B are linguistic values (i.e. low, medium, high) defined by fuzzy sets] For example, "if machine efficiency is high, then manufacturing cost is low"." It is important to note, that the antecedents can have multiple components and there can be multiple logical operators of "and" and "or". The subject matter experts in organizations are asked to write the rules to ensure as much expertise as possible can be included in the logic.[3]

Unahabhokha et al.[4] conclude that the fuzzy expert system has the ability to enable organizations to create systematic ways to predict the future. They also recognize that the process of developing the systems has the possibility of improving the organizations understanding about the real, primary drivers of its operations and to create an understanding about the relationships of the primary drivers.

Fink et al.[5] take a more strategic approach to predictive performance measurement. They note that many organizations have undertaken significant efforts over the course of the past few years to improve their strategy implementation process by implementing e.g. the Balanced scorecard[6] or the Performance Prism[7]. However, they are still being constantly surprised by the changing dynamics of the environment. Fink et al.[8] call for more explicit linkage between the strategy premises, performance indicators, critical marker indicators and change indicators. The graphical illustration of this explicit linkage is displayed below in Figure 10. They point out that the Traditional controlling approach and Strategic controlling approach are not enough in today's fast paced environment. Organizations need to incorporate the performance measurement indicators into the strategy process which not only includes the evaluation of the performance measurement indicators against the Strategy premise but also an evaluation

[1, 2, 3,4]Unahabhokha et al. 2007
[5, 8]Fink et al. 2005
[6]Kaplan and Norton 1996
[7]Neely et al. 2002

of the Critical Market indicators and Change indicators.

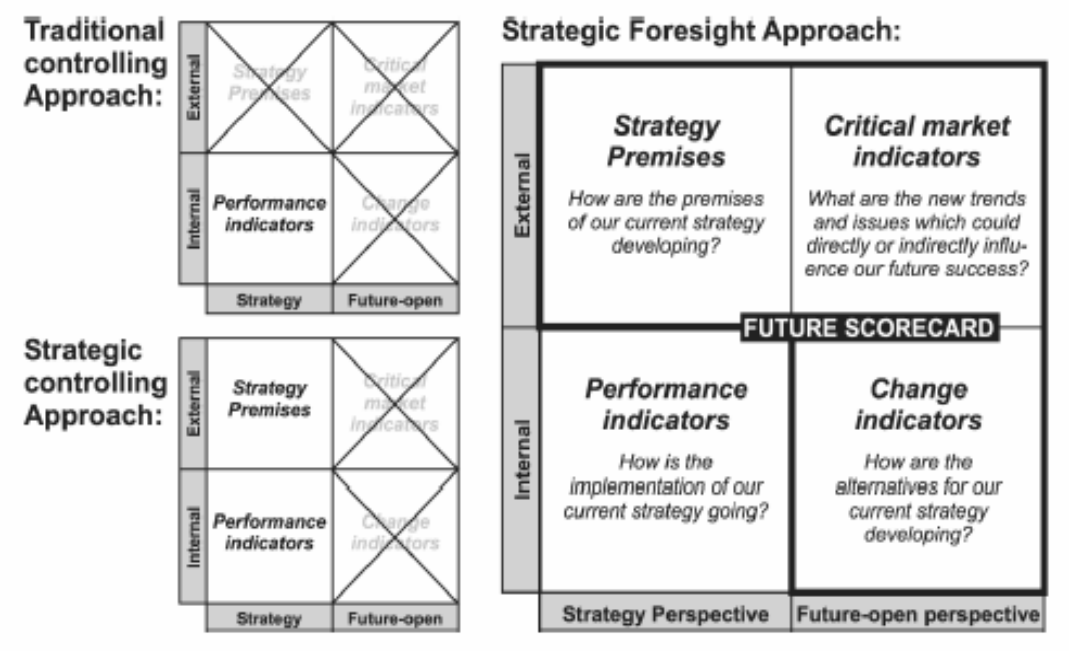

Figure 10 Elements of a future scorecard[1]

[1]Fink et al. 2005

5 PREDICTIVE PERFORMANCE MEASUREMENT

5.1 The synthesis

5.1.1 The premise of performance measurement

Performance is a subjective concept which needs to be understood in the context of the people, organizations, societies and nations referring to it. Performance, especially defining what constitutes good or bad performance is highly challenging as everybody involved carries a subjective understanding about the meaning and nature of performance. The presence of this diversity about the meaning and the nature is very significant in the literature. There is not one definition of performance. Further, it has been suggested in the literature that performance as a concept is only valid in a decision making context. The consequence for performance measurement is that the organizations measuring their performance need to be explicit about how they define performance in the context it is being applied – internally and externally. And, they must demonstrate that the definition ties back to the objectives of the organization.

The first axiom of measurement theory defines measurement as a construction of scales from empirical relationships. It stresses the importance of understanding that a measurement is not the same as the object, the attribute being measured. The second axiom defines the different transformations of empirical relational structures. This is completely in line with the main stream management accounting research literature which has a strong belief in a mind-independent reality. However, the different dimensions of reality have been ignored according to Norreklit et al.[1] who reference that facts, logic, values and communication are the key essentials to making measurement count. Looking moe carefully into what the literature says about individual measures of performance, one can find that the dimension of facts is well covered. However, logic, values and communication have received almost no attention at all amongst the research of performance measures although there is recognition that without them the process of measurement is doomed to fail.

Figure 10 synthesizes the concept of performance, the act of measurement and the

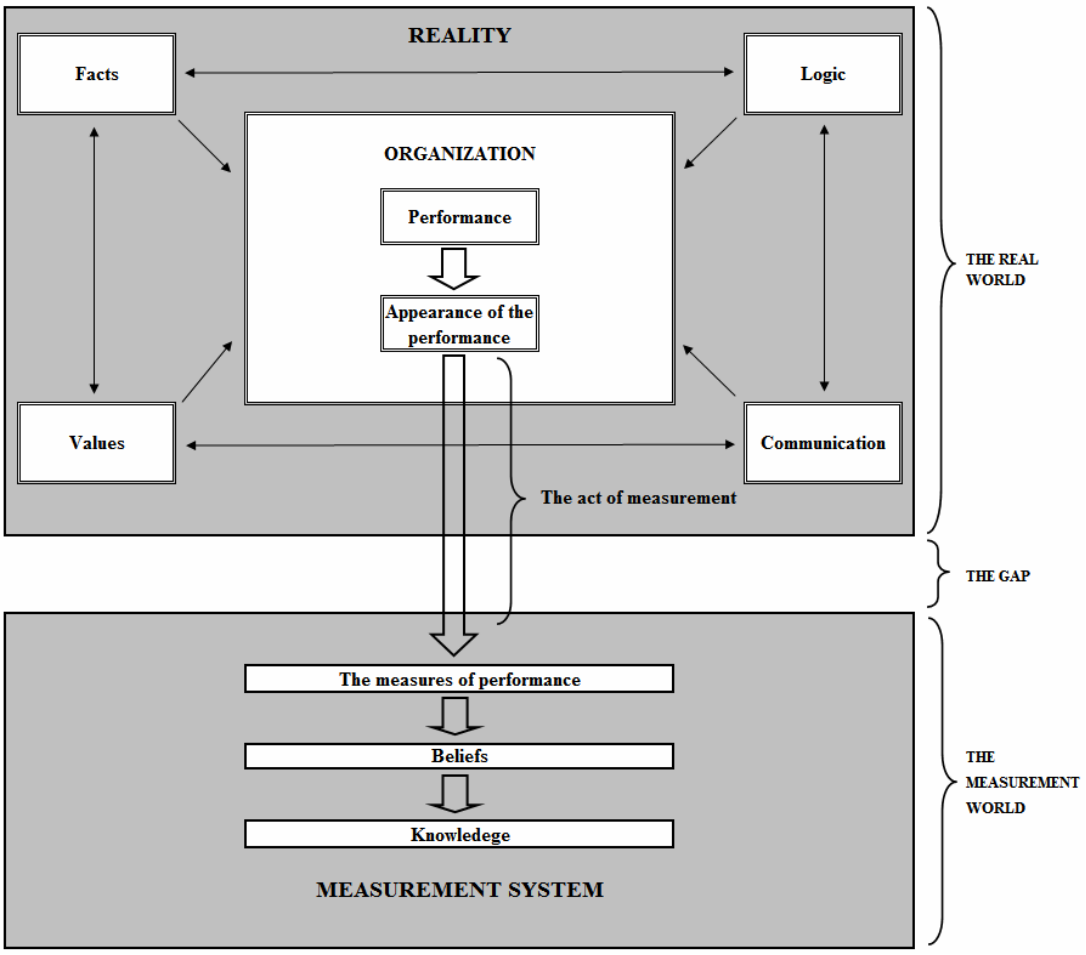

Figure 10 Premise of performance measurement

related issues on measurement theory, the epistemological and ontological considerations, and the dimensions of the reality as presented by Norreklit et al.[1] into a one single view. The performance of an organization – any aspect of it – is being measured and the organization as well as its performance and its appearance reside in the real world. Different measures of performance are used to capture the essence about the appearance of performance to formulate beliefs about the level of actual performance. The act of measurement is subject to the main axioms of measurement theory, as well to the specific requirements the measurement theory poses on

[1]Norreklit et al. 2006

performance measurement, namely completeness, distinctness, independence, agreeability and commensurability as covered in section 2.2. The measurement system needs to fulfil also the criteria set by the concepts of internal and external coherence as described in section 2.3.

5.1.2 Performance measurement systems and contingency theory

Figure 11 introduces national culture, strategy, (organizational) structure and (organizational) size in the context of how, through which channel they impact

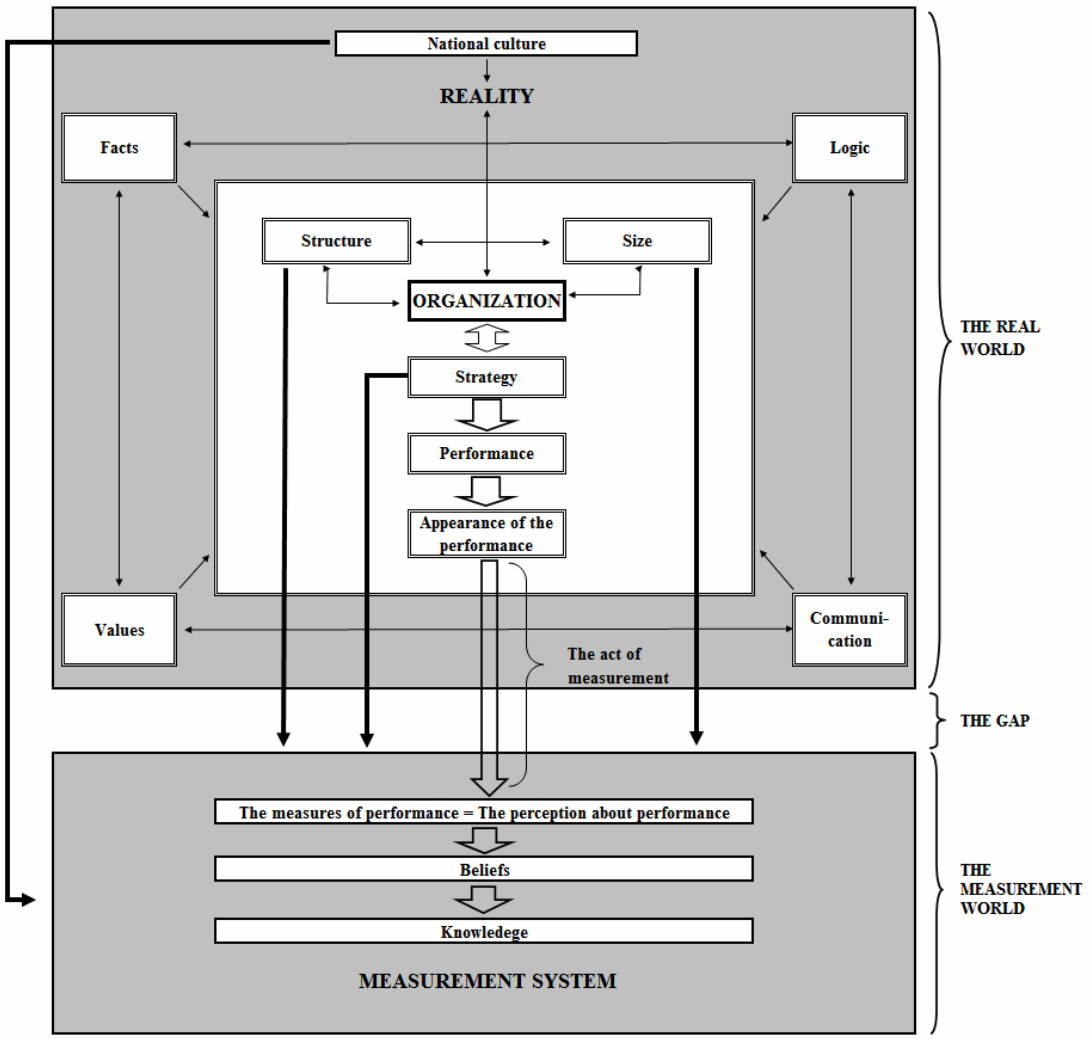

Figure 11 Contingencies, reality and measurement system

performance and consequently the performance measurement system: national culture impacts performance and its consequent measurement and prediction through external reality, the organization and the strategies the organization sets while the other contingencies covered in this research have a direct relationship with the organization.

The more important point to note from Figure 11 is that it displays also the two step effects of contingencies on performance and performance measurement respectively. According to the principles of the contingency theory, organizations seek fit; i.e. in this case the fit of strategy, structure, size and taking the effects of the national culture into consideration as well to maximize performance: this is the direct impact of the contingencies for the actual performance of the organization. The better the fit, the better the actual performance argues contingency theory. The main points of focus in this research are the impacts of the contingencies for the performance measurement system affecting the organizations ability to develop the measurement system into a robust predictive system. These are displayed in figure 11 with bold black arrows flowing from each contingency to the measurement system. This is again a classical illustration about the assumption of mind-independent reality.

Strategy is considered to be the most powerful contingency to be taken into account when designing performance measurement systems: conservative, defender, cost leadership driven strategies need are seen to be in association with more formal and traditional PMS while more aggressive, competitive strategies are seen to be in association with a broader scope of PMS, including a timely integration and aggregation of the system to support operational decision making.

Organizational structure and size have a strong interaction as seen in the literature. Generally, from PMS perspective, large organizations with sophisticated technologies and decentralized, diversified structures are seen to be associated with more formal PMS.

The dimensions of natural culture, of power distance, individualism, masculinity/femininity, uncertainty avoidance and long term orientation have been generally recognized as relevant measures to understand the implications the national culture poses for PMS. However, literature also suggests some methodological

weaknesses in the way culture has been addressed and that extra care would need to be applied if/when general conclusions are to be drawn about the impact of national culture on PMS.

5.1.3 Dynamism, uncertainty and performance measurement

Figure 12 introduces internal dynamism and uncertainty and external dynamism and uncertainty and their relationship with the reality, organization and the measurement system.

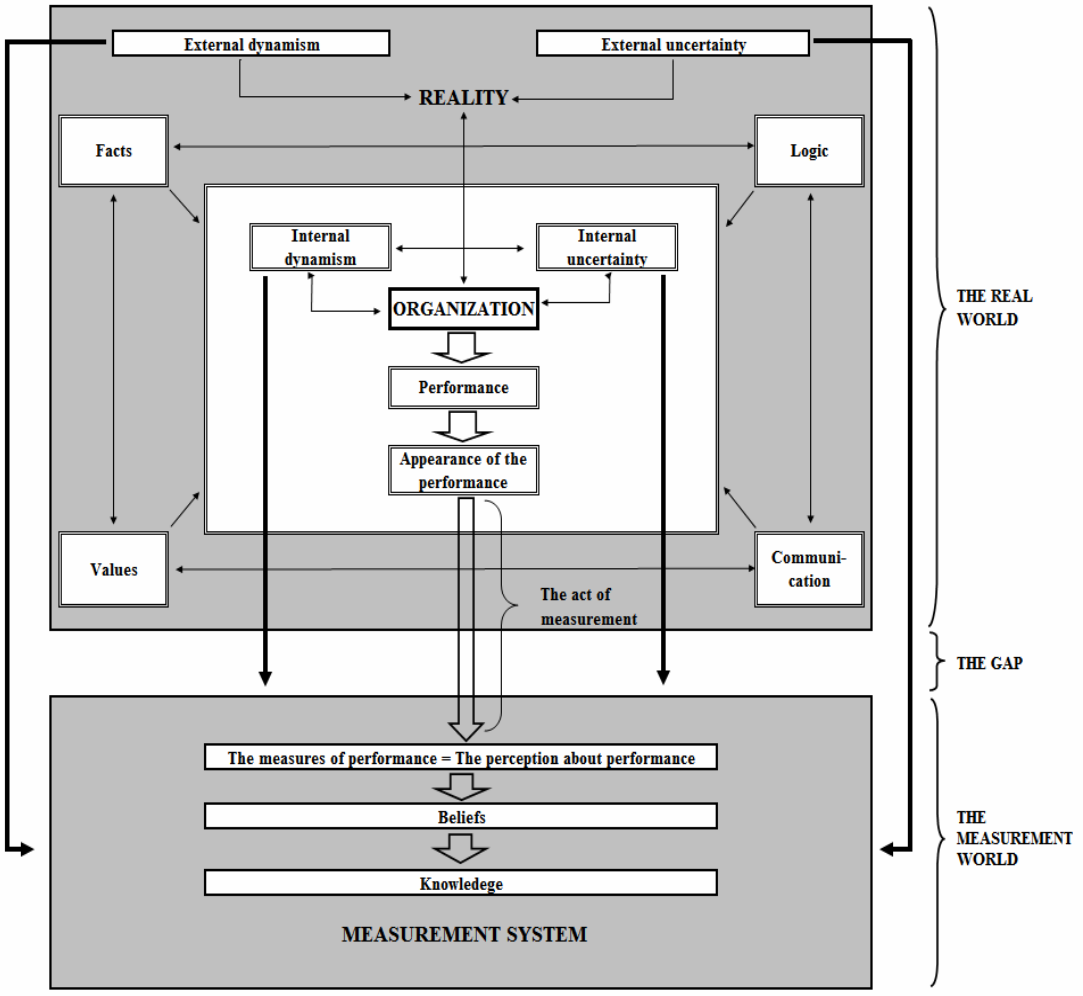

Figure 12 Dynamism, uncertainty and the relationship with reality and organization

First it is important to make a clear distinction between the concepts of dynamism and uncertainty – things can be dynamic but certain. Linear, deterministic, causality, which exists in a dynamic environment, is the basis for the majority of the PMS research. Non-linear, stochastic, causality is what the Chaos theory stands for and has in its core. The debate over uncertainty versus certainty is about the non-linear versus linear world where dynamic vs. static is more or less a question about the time dimension of the world. This distinction has a significant impact because when we introduce uncertainty, the principles of linear causalities aren't valid anymore as such and one needs to allow the process to vary.

The main point from Figure 12 is the same as was with Figure 11. External/internal uncertainty and dynamism drive a direct impact on the actual performance as well as an impact on how the PMS should be formed and how it should be managed for it to remain relevant to a given organization.

Combining the theoretical contributions from the key characteristics and functions of a dynamic PMS[1], the performance paradox[2], the drivers and barriers of change of PMS[3] and the process for managing PMS in an evolutionary manner[4], there exists a very solid base to of knowledge for use in coping with both the internal and external aspects of dynamism.

The question of managing internal and external uncertainty in the context of a valid PMS, especially in a predictive manner, is more complex. The representatives of the Taylorian school still believe that reducing the processes to their basic elements and observing the law-like causalities will give complete predictive power over the future as it is assumed that the cause and effect relationship will stay the same. This has been strongly challenged by physical scientists through the emergence of Chaos theory. The ground-breaking theoretical contributions from Dr Walter Shewhart in the area of theory of prediction inform us that applying the law-like causalities in dealing with uncertainty and consequently using the same law-like generalizations for prediction in today's business environment is inherently flawed. However, it is Shewhart himself

[1]Bititci et al. 2000
[2]Meyer and Gupta 1994
[3, 4]Kennerley and Neely 2002

who points out that as the mathematicians have taken over the concept of prediction - referring to prediction applying pure stochastic modelling in isolation of business insight – has led into a situation where the real relevance of prediction has been lost. This research argues, on the path shown by Dr Walter Shewhart and the Chaos theorists, that one should abandon the strict determinism and also avoid the other extreme where business economics and prediction is but a pure statistical exercise.

5.2 The framework

Combining what has been introduced through Figures 10, 11, and 12 this research proposes a framework of factors affecting the creation of a predictive performance measurement system (Figure 13). The proposed framework has two main elements. The upper part is the real world and the lower part is the measurement world which represents the PMS. The components of the theoretical frame of reference are all leveraged; everything goes through performance, the act of measurement regulated by the measurement theory combined with the appearance of the performance and the perception about the performance (the measures of performance) have a central grounding in the framework – composing the actual act of measurement displayed by the red box in the framework. The perception about the performance, beliefs and knowledge ties back to the epistemological and ontological considerations. Organization, incorporating performance, is seen to reside in real world which reinforces the principle of mind-independent reality also on behalf of this research.

The four fundamental dimensions of reality; facts, logic, values and communication; serve as the corner stones in the framework. Without them in place completely and properly failure is predicted. All the contingencies have their place as well. The external/internal dynamism/uncertainty effects are outlined with direct impact on actual performance and secondary impact on the measured performance through their affect on the characteristics of the PMS.

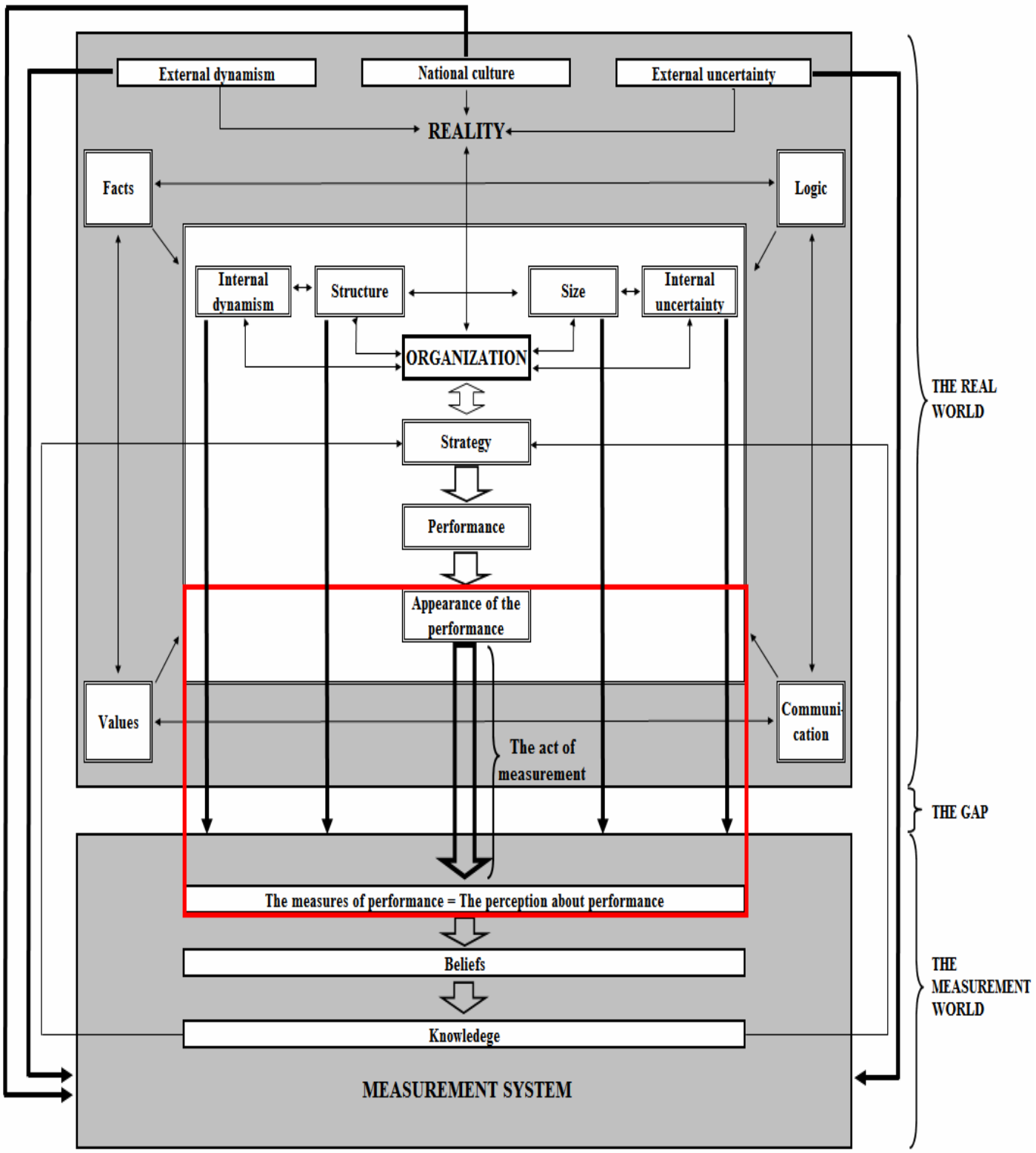

Figure 13 The framework of factors affecting the development of a predictive performance measurement system

5.3 Developing a predictive performance measurement system

The development of a robust predictive performance measurement system begins with an explicit recognition of the duality between the real world and the measurement world and recognizing the gap which at face value exists between the worlds. What makes the gap to grow in its existence is that the measurement world and the measurement systems traditionally ignore the soft side of the real phenomena as well as being purely focused on consequences rather than drivers. This research argues following the path of Norreklit et al.[1] that without the explicit recognition of the four corner stones - facts, logic, values and communication - when a measurement system is being developed, the robustness of the system will never reach the level where the system would be capable of serving as a trustworthy premise for prediction. This is because the developed measurement system is not going to be rooted in the real world and in its phenomena and people but in the consequences of the measurement world an as such will not be a complete representation about the reality where organizations reside. If this first step of practical integration, rooting the measurement system into reality – into an explicitly defined and agreed facts, logic, values and communications –base - which also needs to be shared across the stakeholders – is failed, the act of prediction is to fail as well as robust prediction in a consequential mode of operation without the proper linkage to real world is impossible.

Second, it is suggested that once having the four corner stones in place, the organization needs to consider the contingencies and the internal/external dynamics/uncertainties. The four corner stones will allow the organisation to operate in an integrated manner as the common and real base exists. Building on top of this common base, the organization is able reflect properly over its contingencies and select the most suitable characteristics for its performance measurement system and to build a capability to further reflect and modify its measurement system once the drivers of change start to impact either the base or the contingencies.

Third, considering the increased uncertainty of today's globally integrated marketplace, an organization needs to build a capability to map and analyze its key processes,

[1]Norreklit et al. 2006

especially their variation as a function of time to be able to model and recognize the root causes of the variances in the respective key processes. History cannot be directly used to predict the exact future outcomes but it can be used as a supporting starting position.

5.4 Predicting performance

Knowing where an organization is in relation with its internal and external reality is an absolute prerequisite for successful prediction. Unless the starting position is understood and known there is a very, very limited possibility that the future predictions will be accurate. The constructed framework tackles the issue in three ways:

i. It makes explicit the areas to be considered when an organization takes on the challenge of developing a PMS system which needs to be relevant to the organization's internal and external reality (establishing the valid starting position for prediction)
ii. It makes explicit the areas to be considered when an organization takes on the challenge of making sure that it's PMS is relevant now and in the future and that the PMS will be capable of responding to the changes in the external and internal reality of the organization (ensuring that prediction will have the valid starting position also in the future when the context changes)
iii. It makes explicit the two-dimensional power nature of the contingencies and the internal/external uncertainties/dynamics which drive the actual performance of the organization (facilitates establishing the drivers of the base).

Once the organization knows where it is in relation to its internal and external reality and it has greater certainty that it will also know in the future at each point in time where it is in relation to its internal and external reality, then the focus can be confidently turned to predicting today the organization's future.

This research argues that there are several underlying forces in regards to the actual act of prediction which can be observed either directly or indirectly from the proposed

framework (Figure 13) for understanding factors affecting the development and application of a predictive measurement system:

i. Complexity
ii. Multiple second, third or even fourth order interdependencies (e.g. external dynamism-reality-organization or values-internal dynamism-organization)
iii. The feedback and feed forward nature of information flows
iv. The closed looped nature of the predictive performance measurement process
v. The power the predictive performance measurement process possesses in an organization, within the given internal and external reality, is a function of the degree of internal and external integration.

Complexity is visible already from first view of the framework. There are multiple parallel factors that organizations need to consider. The statement follows the path of Chaos theory arguing that organizations operating in the global marketplace are such a complex entities that one cannot reduce it to its basic elements, which in turn would enable pure deterministic prediction. The multiple second, third or even fourth order interdependencies (e.g. external dynamism-reality-organization or values-internal dynamism-organization) are a consequence from the first one and as such describe why a modern organization is not a Taylorist machine. The number of relationships is the challenge an organization needs to understand to be able to formulate a holistic overview of its relation to its internal and external reality. The second, third, or even fourth order interdependencies can be too complex to handle for most organizations. However, this is one area where an organization has a chance to make the difference: even considering the key internal and external forces and clearing out the map around them until e.g. the third order can prove to out of great value for the organization. This map is also required when an organization is reviewing its key processes and developing the consequent control charts displaying process variation of its key processes as a function of time.

The feedback and feed forward natures of the information are directly visible in Figure 13. The closed looped, iterative nature of the predictive performance measurement

process is described via the connectors from knowledge to strategy. This is to display that the knowledge and experience gained through the process of predictive performance measurement is fed back into the decision making process. The organization is constantly updating its knowledge base.

The fifth and the last point is arguably the most interesting one. The general reference is originally made by Norreklit et al[1] while this research has applied the logic in a bit different context. What is meant with the degree of internal and external integration is that how well the organization will be able to create and maintain a joint language and mode of joint end to end execution between the financial and non-financial managers, how well the organization is able to create the atmosphere where individuals do act in the best interest of the organization according to the jointly agreed objectives and how well the organization is able to interact with its external environment. This question of internal and external integration as a key enabler of robust prediction will be covered in a more detail after first considering the actual methods in a more detail.

In this research, the essence of the actual method and operational execution of prediction reduces down to understanding and interpreting process variation. Statistical control charts which display the process variation as a function of time were introduced in section 4.3 in order to enable management to distinguish between the chance and assignable causes of process variation to see if the process can be considered to be in control. Building the capability of being able to produce statistical control charts in a regular manner is also the last key item when a predictive performance measurement system is being developed. If an extreme position is selected, there is no value predicting an outcome of a process which continuously displays assignable causes as predicting them poses a great challenge and ability to do so is something that lies outside the predictive capability of statistical control charts. This provides another valuable insight into the art of prediction: organizations have to be able to make a clear distinction of predicting the regular, standard but stochastic process deviation from the prediction required coping e.g. with the game changing new market conditions. Consequently, understanding the nature and source of process variation is of paramount

[1]Norreklit et al. 2007

importance. The control charts can be used to predict the outcomes of the existing processes and their outcomes but they are unable to foresee the impact of the assignable causes.

The approach described by Fink et al.[1] provides a greatly valuable starting point for an organization to start developing a capability of being able to predict the assignable causes as an additional dimension of integration. Fink et al.[2] combine performance measures, strategy premise, critical market indicators and change indicators into a future scorecard which is capable of dealing with greater than three sigma variations against the average outcome of a process. The scorecard is based on open systems thinking, meaning that the deterministic assumptions have been abandoned by Fink et al.[3] as well.

While the control charts and the future scorecard are considered as methods to enable and perform prediction it is as well of utmost importance to consider what are the essentials in making sure that the methods whose value add to an organization is theoretically indisputable can be also leveraged in the operational value generation through the practical act of integrating the stakeholders of the prediction process. This research suggests that the operational transformations of financial targets, forecasts and actuals should be considered as the words of the integration language; the language that should be used in the discussions when the organizations take on the challenge of developing and applying a predictive performance measurement system. The operational transformations of the financial targets, forecasts and actuals are something that everybody can relate to, especially the non-financial managers whose first order responsibilities are to manage the phenomena of the real world, the drivers of the measurements, in this case the drivers of the financials. If the discussion and language used between financial and non-financial managers is only about absolute revenue, cost and the consequent profitability, an organization runs an imminent risk of only measuring what it can, not what counts. The operational transformations of the financial targets, forecasts and targets can be considered as the vehicle to bridge the gap which exists between the real world and the measurement world. The key is to realize that this act of integration happens with a movement whose direction is from the measurement

[1, 2, 3] Fink et al. 2005

world to the real world whereas the direction of the movement of a traditional act of measurement goes from real world to measurement world.

Another direct benefit of applying the operational transformations of the financials as an integration language is that the approach links directly back the control charts and future scorecard as the respective two methods are based on process level analysis and open systems approach. This results a situation where operational targets are set in a rationale manner, which ties back to the financial targets. Actual, real world improvement opportunities can also be leveraged better in the financial target setting. An organization is to consider what is achievable taking the real world phenomena and the maturity and status of its key processes into consideration, while the finance and planning organization will be directly capable of supporting this integrated predictive performance measurement as the operational transformations of the financials can be directly transformed back to actual financial figures as well.

Finding a common language between the financial and non-financial is not the only act of practical integration that needs to happen for the act prediction to turn into a robust process.

On the way to integrate the financial and non-financial managers around the process and systems of predictive performance measurement, an organization needs to also make a clear commitment that the predictive system itself is used as a vehicle of improvement. Once the focus is turned to learning, relative, rather than absolute improvement over the previous period and on interpretation rather than control and judgement, the required social interaction enabling the integration inside an organization starts to incur and reaction is transformed to proaction. Predictive performance measurement, its robustness, is a process that is greatly more dictated by its social dimensions than the technical ones.

6 CONCLUSIONS

6.1 Limitations of the research

The exclusion of the individual level compensation aspects combined with the assumption that individuals are always assumed to act in the best interest of their organizations are significant ones. It is recognized that performance measurement systems and the individual compensation need to be explicitly tied into the organizational success. The question, that how an organization can best ensure the appropriate alignment of its performance measurement system, individual compensation aspects and organizational success was not covered in this research while the research recognizes that it is a major dependency making the act of prediction work in a robust manner.

This research also adopted the approach that predicting performance in the most valuable manner is not a complex mathematical act. However, it's recognized that there are many who openly support the highly developed and complex mathematical and statistical models run purely by computers based on given set of input variables. While this research recognizes the existence of such models and that under certain specific conditions and in certain industries they are capable of adding real value, e.g. in financial services industry; the conditions are not that many. Regardless of the complex world where relationships of different organizational components cannot be reduced to their basic elements, the critical few processes should still be the driving force of prediction. Not a computerized, technical model incapable of dealing with the social aspects of predictive performance measurement.

6.2 Avenues for future research

This research has outlined a framework of factors affecting the development and application of a predictive performance measurement system and two underlying scientific extremes have been identified as the basis: the Newtonian school of science which argues the world to be a deterministic one and the Chaos theory which argues the

world to an inherently uncertain, a stochastic one. A question that could not be answered in this thesis is that does there exist an equilibrium model, incorporating the best of the both of the scientific extremes. Consequently, a greatly fruitful avenue for future research both from academic, theoretical as well as from a practising professional perspective would be to search for a dynamic equilibrium model. The need for a model incorporating the best of both extremes is argued based on the fact that a great majority of the current measurement systems are still ran with certainty at their core and a drastic transition to fully incorporate all the dimensions of uncertainty into the current models theoretically correctly is not just practically possible. It can be argued as well, that the deterministic, Taylorist, assumptions carry value when building the premise of a predictive performance measurement model, which is then ultimately to be run with uncertainty in its core and which also supports finding the right balance between the two approaches.

The dynamic equilibrium model could be developed based on the fundamentals of the framework develop in section 5 of this research. Using the developed framework as the premise, proceeding then to identifying the key deterministic internal and external causalities of a given organization and finally incorporating dynamism and uncertainty into the model via applying the principles of the chaos theory has the potential to result an end to end management system allowing real time control of strategy execution while being responsive to the inherent change of the globally integrated marketplace. A dynamic equilibrium would allow the organization to continuously reflect on the success of its intended strategy as well as to ensure the necessary changes driven by changes in an organization's strategy premise or in the market conditions to its intended strategy are executed in an appropriate manner.

6.3 Final remarks

An organization needs to define what it expects from its measurement system. If control and judgement are all that is required, the one way interaction from real world to measurement world, via the act of measurement itself is enough. This approach is described by measuring only the consequences, in financials namely revenue, cost and the consequent profitability of an organization.

If an organization expects its measurement system to provide predictive business insight, several activities need to be performed and continuously executed to enable the delivery of such insight. The premise for a predictive performance measurement system needs to be created via explicit recognition of the facts, logic, values and communication. The contingencies need to be considered and the system needs to be able to deal with dynamic internal and external environment as well as with uncertainty. Most importantly, an organization needs to develop a common language for the financial and the non-financial managers while recognizing that predictive performance measurement is ultimately greatly more driven by organization's social rather than technical abilities.

C. I. Lewis[1] has said: "Knowing begins and ends in experience; but it does not end in the experience in which it begins."

The quote illustrates the relationship between knowing and experience which further emphasizes the social nature of predictive performance measurement. Knowing and decision making are iterative processes which are driven by the experience of a decision maker. Strategy formation, strategy execution and decision making processes need information and knowledge to support them; they need decision support. Knowing is a question of having the right information available which ultimately needs to convey the right experience to the decision maker to enable efficient and effective decision making and execution – information and knowledge as such are not enough, while they are of course necessary conditions for success but it's the decision makers experience that ultimately drives success or failure. Consequently, when an organization targets for delivering predictive business insight via its measurement system to its decision makers, the integration necessary to enable the respective delivery reduces down to integrating the measurement world and the real world. It needs to be ensured that the predictive performance measurement system will be able to capture all the relevant knowledge and experience that a decision maker has to offer and to merge this with the predictive system's own ability to acquire information about the real phenomena to enable the delivery of the predictive business insight.

[1]Lewis 1929 in Shewhart 1939 in Wilcox and Bourne 2003

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APPENDICE 1: CRITERIAS TO ENSURE THE EFFECTIVENESS AND EFFICIENCY OF A MEASURE

By Neely et al. 1997.

a) simple to understand
b) have visual impact
c) focus on improvement rather than variance
d) visible to all
e) be derived from strategy
f) provide timely and accurate feedback
g) relate to specific, stretching, but achievable goals (targets)
h) be based on quantities that can be influenced, or controlled, by the user alone or the user in a co-operation with others
i) be clearly defined
j) be part of a closed management loop
k) have an explicit purpose
l) be based on explicitly defined formula and source of data
m) employ ratios rather than absolute numbers
n) use data which are automatically collected as part of a process whenever possible
o) be objective – not based on opinion