RE-THINKING INNOVATION MEASUREMENT TO MANAGE INNOVATION-RELATED DICHOTOMIES IN PRACTICE

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ABSTRACT

Innovation performance measurement has developed from focusing on issues of control and monitoring towards a more supportive role for managers on a strategic, informative and motivational level. Despite its potential to facilitate innovation management measuring provides a challenge in practice not the least when a company has the ambition to manage both radical and incremental innovation. This paper, based on literature review with empirical illustrations from three case studies, argues that these issues derives from the need to manage a number of dichotomies which are present due to the essential differences associated to each type of innovation. These dichotomies are related to time, uncertainty, flexibility and control. The implications on the design and use of an innovation performance measurement system are explored and analyzed through the lens of dichotomies. The study contributes to the innovation measurement theory and provides basis for an analytical framework aiming to support the design and implementation of innovation performance measurement in practice.

Keywords: Innovation management, Innovation performance measurement, radical and incremental innovation

1. INTRODUCTION

Performance measurement, understood as the ability to measure both effectiveness and efficiency of the actions of a company, has its roots in accounting and traditional management where financial control and diagnostic purposes for measuring dominates (Lebas, 1995; Bourne et al, 2003). Research emphasize the use of measurement also as a strategic tool to motivate and inspire new behaviors as it has shown to have the potential to support team-autonomy and by providing a priority agenda, as well as stimulate a forum for the generation and implementation of creative ideas (Simons, 1990). If appropriately designed, performance measurement can help managers´ mental representations of the business, provide goal and process clarity, as well as encourage extensive scanning behavior (Gimbert et al 2010). Performance information has also shown to affect intrinsic motivation and empowerment through creating meaning and supporting an increased understanding on how a particular action fits within the broader scope of the organization (Hall, 2008). Despite its potential to facilitate management, measurement is considered a challenging area in practice and measuring innovation is particularly challenging as innovation is complex, multidimensional, and unpredictable (Murray and Blackman 2006; McCarthy et al 2006),creating specific requirements on what and how to measure.

Innovations can be argued to vary along a continuum from incremental to radical where incremental characterizes innovations within a certain paradigm, while radical is associated with innovations that drastically changes existing practices (Dewar and Dutton 1986). The differences in management practices required to support radical and incremental innovation respectively are caused by the need to pursue both exploitation and exploration activities (March, 1991) which require substantially different structures, processes, strategies, capabilities and cultures in the company and which have different impacts on firm adaption and performance (McDermott and O'Connor 2002; He and Wong 2004). These managerial differences provide a particular challenge for companies that see a need to simultaneously manage radical and incremental innovation not the least when allocating and combining resources to support each. Research literature is extensive in describing implications on management when building these different or dual capabilities (Bessant 2011; O´Connor and DeMartino 2006; Gupta et al 2006; Tushman and O'Reilly 1996). The difficulties when managing both radical and incremental innovation can be described as a consequence from the need to manage a number of dichotomies or dualities resulting from the inherent essentially different characteristics of radical and incremental innovation. Dichotomies or dualities refer to polar opposites that often work against one another in an organization i.e. the choice to focus on one of the poles creates a tension and a difficulty to enact both ends of the continuum simultaneously (Poole and Van de Ven 2004).

Considering the close relationship between management and measurement, these dichotomies will provide a challenge for measurement as well. The same research focus would thus be expected to apply also on innovation performance measurement as it needs to be adapted and developed to match management challenges and needs. However, literature is remarkably scarce in discussing implications for measurement. Based on this observation a question in need of investigation is consequently: What are the implications of an explicit ambition to combine radical and incremental innovation for the design of innovation performance measurement?

The aim of this paper is to contribute to the advancement of the innovation measurement theory by assuming the importance of understanding the dichotomies present when simultaneously manage radical and incremental innovation when identifying issues concerning the design and use of innovation performance measurement in practice. Incremental versus radical innovation is in this respect an overarching dichotomy, and though not covering the full area of innovation management literature or the complete picture of innovation, this work explore four dichotomies which are argued to be critical in the design of innovation performance measurement. The dichotomies relate to uncertainty, time, flexibility and control, and are analyzed and discussed in relation to innovation measurement literature.

A description of challenges related to measuring innovation facing three international high technology companies with the ambition to realize both radical and incremental innovation are also included as empirical illustrations. The result is input to an analytical framework that in subsequent studies will provide basis for the design and implementation of innovation performance measurement in practice.

2. METHOD

The study aims to provide a theoretical basis for factors to consider when designing and using an innovation performance measurement system that supports companies with an explicit ambition to combine radical and incremental innovation.

A literature review was an important foundation of this paper, focusing on two main areas: Innovation Performance Measurement and Innovation Management. The measurement area was searched in order to understand state-of-art, in particular for support of innovation management in an industrial setting, and to identify issues specifically concerning how 'measurement of innovation' *support* 'management of innovation'. The search of the second area was directed by the aim to understand management of both radical and incremental innovation and specifically by the understanding that there are many dichotomies underlying the radical versus incremental dichotomy. Thus, the search strategy, including a range of electronic sources and databases, used a broad set of search criteria, continuously converging to dichotomies identified. As the core of the study concerned relation between measurement and management of innovation no full screening of the management literature was made and the ambition was to find critical dichotomies and not "all". Literature search was done repeatedly in the team and identified and selected dichotomies were analyzed by at least two authors.

Knowledge of three of the authors, being employed in international high technology companies has accompanied the literature study, and specifically directed the selection of dichotomies to be of critical importance to the management of innovation. In addition, empirical data reflecting the practical side of the focused areas has been collected from these companies. The analysis of this data is used to illustrate challenges when innovation performance is measured in practice. Data collection has been made through observations, interviews in former studies and through access to formal documentation within the companies.

3. PERFORMANCE MEASUREMENT AND INNOVATION

Several conceptual frameworks for performance measurement based in operations management emphasize the necessity to measure more than financial performance, such as innovation and learning (Neely 2005). The Balanced Score Card is among the most common and well-researched models (Kaplan and Norton 1992) which has inspired similar approaches also within R&D and innovation management (Kerssens-van Drongelen and Bilderbeek 1999; Adams 2007). Other models relate to an innovation process or model (Cordero 1990; Brown and Svensson 1998) or represent auditing approaches (Chiesa 1996; Hallgren 2009). Innovation measurement literature stress the importance to measure a wide number of factors and phenomena including areas like innovation strategy; ideas and ideation; customer and market; organizational learning and knowledge management tools; and organizational culture and leadership (Adams et al 2006; Crossan and Apaydin 2010). Despite the extensive amount of research, measuring and assessing innovation performance to fruitfully manage innovation remains a problematic area in companies (Adams et al 2006; Kianto 2008) which becomes an even greater challenge when considering the need to accomplish both incremental and radical innovation.

Problems in practice are related to understanding what to measure, i.e. to identify the right measures in order to evaluate, not only the result of innovation activities, but also the efficiency of processes in getting new ideas commercialized and to assess the returns on investments (Smith 2005; Adams et al 2006; Christensen et al. 2008). Further complicating these problems are the fact that many companies lack an insight in the right combination of intangible and tangible resources that will enable a strategic development of innovation capabilities leading to competitive advantage.

Measures that support evaluation and selection of innovation projects of different type and nature, and its subsequent resource allocation and process management, constitutes another challenge in practice. For the majority of companies, the models and tools in use to manage their projects and project portfolios are based on traditional financial tools like return of investment and net present value which are less suitable since data on innovation output and outcome are difficult to characterize and predict and become visible, if at all, first at distant in time (Christensen et al. 2008). This is especially true for innovations of radical nature which leads to companies becoming biased to ideas and projects more familiar to existing products and processes i.e. incremental innovation.

Other problems present in practice are related to understanding how to get access to and collect the data and information needed to enable learning and decision making in order to optimally manage innovation. This is due to the fact that important aspects or critical factors of innovation such as knowledge, ideas etc. cannot be measured directly due to its intangible character and because the processes of measuring innovation related activities and intangible assets would require significant changes in internal practices and methods (Edvinsson et al. 2004; Smith 2005). As a result, it has been found that companies seldom track information needed to evaluate and assess innovation in a systematic way and that even those that do have very different methods and perspectives which makes it hard to compare and benchmark innovation performance between companies and organizations (Bourne and Neely 2003; Adams et al. 2006; Tidd 2001).

A consistent finding in research is the importance to link performance measurement with the strategy of the company in order to provide business value (Kaplan and Norton, 1992; Neely 2005; Micheli et al. 2010). Introduction of new performance measures and indicators can if appropriate managed act as a catalyst for implementation of new strategic objectives and enable change management initiatives. Further, performance measurement literature shows the importance of understanding appropriate measurement practices since it is the combination of what to measure with how it is measured that will provide the benefits (Bourne and Neely 2003). It has been found that the different roles of measurement and each measure need careful consideration, especially when a company is involved in processes of substantial transformation as a lack of clarity regarding its intended use will create considerable problems which may eventually become contra-productive (Melnyk et al 2010). Also, the design will depend on the environment in which the organization operates, its links with key stakeholders, and the implications the measurement system may have in maintaining the current, or shaping the future, organizational culture (Chiesa et al. 2009; Micheli et al. 2010; Henri 2006).

Other critical factors to consider are the procedure for identifying and implementing measures. Bourne and Neely (2003) categorized the procedures in three groups; audit driven, considered a bottom up approach; need driven, considered a top down approach where the Balanced score card provides a typical example and model driven where a pre-defined process or model provides the basis to identify measures. Depending on the purpose or preference different companies make use of different approaches.

4. MANAGING INNOVATION DICHOTOMIES

4.1 UNCERTAINTY

Uncertainty is not only associated with risk, or the possibility of several outcomes for a situation (Loch et al. 2008), but also to complexity and unfamiliarity in relation to a subject or situation (Bordia et al. 2004). In addition, uncertainty implies a lack of information (McLain. 2009). In development of new products and services the processes strive to reduce uncertainty for maximal performance; however, uncertainty, diversity, or turbulence within an organization are sources of creativity and long-run viability for an organization (Van de Ven 1986). In one way, uncertainty creates a positive tension in which creativity can flourish, but on the other hand it may also be the cause of anxiety and reduce productivity, especially when related to roles and structural changes (Bordia et al. 2004).

Managing both incremental and radical innovation project implies the balancing of certainty, to reduce risk, and uncertainty to foster creativity although for radical the level of uncertainty due to the inherent novelty characteristics will be accentuated. Uncertainty can be related to technical, market and project scope risks (Davila 2000), and to risks related to resource scarcity or lack of knowledge (De Maio et al 1994) and each of these aspects is associated to different strategies and management practices. Considering radical innovation being associated to all types of risks and not the least to a high level environmental and market uncertainty in contrast to incremental innovation it provides a particular challenge for management.

For incremental innovation the level of uncertainty will differ with the development process; it will peak in the initiation stages and become close to zero at the commercialization stage. Radical innovation will not follow the same path, since there is no pre-defined process or dominant design (Abernathy and Utterback 1975). Instead these innovations emerge over time and cannot be predicted in advance and the level of uncertainty remain high even beyond a radical innovation is commercialized since the adoption can take time (O'Connor and DeMartino 2006).

Companies that strive to generate radical innovation need to learn how to expand their search field and how to interpret weak signals in order to identify potential new business opportunities and threats (Teece et al. 1997). For incremental innovation, the direction and objectives are set from start why the search for solutions is preferably performed within known areas (Bessant 2008). The strategic fit is thus not an issue when managing incremental innovation in opposite to radical innovation which may challenge not only the strategies but even the existing business model of a company.

4.2 *TIME*

One dichotomy that stands out as critical to manage and that will have a large influence also on measurement is how to manage the different time perspectives present when aiming to manage both radical and incremental innovation. Radical innovation typically requires a persistence to invest for more than a decade before it becomes profitable (Gilbert et al 1984; Quinn, 1985) in contrast to innovations of more incremental character. Long-term adaptability thus require risk-taking and seeking cutting-edge innovation to achieve the company's long-term viability and sustaining their competitive advantage. This may generate new businesses and foster long-term financial success. On the other hand, a company needs to generate incremental innovation to be able to survive and ensure financial profitability in the short-term. The literature is in agreement that both perspectives are needed and that the implication is that two different strategies are needed (Andriopoulos and Lewis 2010; Martinich 2004). A mix of products in the product portfolio is needed which strongly influence how decision

making needs to be made in the management of ideas and project portfolio (Corso and Pellegrino 2007). Companies with an explicit strategy to manage both radical and incremental innovation are thus facing an important dichotomy; how to make appropriate allocation of resources to support each type of innovation.

Yet another time perspective in need of proper management is the irregularity of how radical innovation project are developed; the radical innovation process is characterized by an "irregular and unpredictable rhythm" if compared to the more path dependent and ordered incremental development process (Bessant et al 2011). This put demand on the type of measures and not the least on how fast and adaptable the measurement system can be built. Finally, since many traditional manufacturing companies, have identified the development of product related services as one important approach in identifying more radical solutions, the difference in time perspectives between product development and services needs also to be considered. Products are first produced, and then used, whereas services are produced, and used, at the same time (Morelli 2002) which implies challenges when managing and measuring integrated product-service innovations and not only traditional products.

4.3 *FLEXIBILITY*

Both the difference of level of uncertainty and the different time horizon and rhythm characterizing radical and incremental innovation representatively put demand on the companies to also identify appropriate organizational designs, processes, structure and strategies to support each type (Tushman and O'Reilly 1996; O'Connor and DeMartino 2006). Research is rich in descriptions on how the majority of radical ideas in large established companies have a hard time to reach the market phase (Dougherty and Hardy 1996; Leonard-Barton 1995). Nurturing ideas that takes long time before they (if ever) give financial return, are out of scope for core product areas, does not fit existing operations and that may challenge the current business models require an allowance of a high level of flexibility in a companies' processes and structures.

The sequential models or stage gate models underlying many company's product innovation processes have potential advantages as they can be instruments for developing systematic and easy-to-learn best product innovation practices (Cooper, 1993) and has shown to benefit the development of incremental innovation. However, as sequential models rely heavily on planning and are means of controls through standardization, the creativity and learning required in the development of more radical innovations are at risk. The mechanistic approach brings a focus on process efficiency and does to a large extent ignore how process factors such as flexibility, informality, feedback, and autonomy might influence innovation (Nonaka 1994; Dougherty and Hardy 1996). More flexible, integrative and improvisational models that takes into consideration the more complex and dynamic events present in practice are thus needed. The management practices developed to support the management of radical innovations are based on a fast failure and learn approach to gain insights into what combination of intangible and tangible resources will lead to competitive advantage (McDermott and OConnor 2002).

This flexibility and informality is also emphasized when it comes to the organizational structures i.e. the relations between individuals and teams, internally as well as externally that need to be created in order to create the knowledge needed to support radical innovation. The encouragement of "weak ties" (Granovetter 1973); heterogeneous and informal relations have been found to stimulate more novel and creative solutions and provides thus an opportunity

for radical innovation (McDermott and O'Connor 2002). This stands in large contrast to traditional product development literature which emphasizes the enhancement of existing relations with customers and suppliers through the use of formal cross-functional teams.

4.4 *CONTROL*

To enable opportunities for both incremental and radical innovation, an appropriate balance in flexibility and stability is thus needed to support both radical and incremental innovation. This needs to be reflected in the use of the lever of controls in the company and the traditional hierarchical mechanisms are seen replaced with alternative models. Opportunities for radical innovation typically emerge from employee engagement and initiatives; skunk works (Peters 1997), intrapreneurs (Menzel et al, 2007; Burgelman 1983) or bottom-up (Birkinshaw et al 2011; Smeds and Haho, 2003) where incremental innovation is a result of more traditional control and planning exercises.

Day (1994) found that companies can, with a principal champion/intrapreneur from the lower levels of the organization, achieve radically innovative results. But these lower level champions need sufficient knowledge and access to information to make the critical decisions, as well as sufficient power and influence to obtain resources necessary. For companies that require substantial resources during development, principal champions from top management are important for to achieve radically innovative results. In other words, successful radical innovation needs both freedom and control; bottom-up initiatives need the support from top management to survive (O'Connor and DeMartino 2006).

Results from a large amount of research studies as well as from international large scale management consulting surveys consistently show that creating an innovation culture is a key success factor for companies when managing their innovation effort, not the least for radical innovation (Booz&Co, 2011; Tellis et al. 2009). Radical innovation, characterized by a high level of uncertainty and risks which may require more than a decade before (if ever!) generating profits is in need of a high degree of creativity and persistence to survive as earlier described why incremental innovations are more dependent on improving and deepen existing competences, skills and relations (Amabile et al. 1996). These dual set of values and norms need to be reflected in the reward and recognition system in place in a company as these systems have shown to have a significant impact on a company's culture.

The difference between radical and incremental innovation in relation to the key dimension of each dichotomy is found in Table 1.

DIMENSION IN DICHOTOMIES	**RADICAL**	**INCREMENTAL**

Uncertainty Technical Market Project scope Strategy Resources	High risk and high uncertainty Market uncertainty will remain high beyond a radical innovation is commercialized New business opportunities and early warning through weak signals of emerging trends May or may not fit existing strategies and may challenge current business models.	Low risk and low uncertainty Market uncertainty will be low during the whole innovation process and very low during commercialization Systematic search within familiar areas Always aligned to strategies and current business models
Time Long and short (Length) Discontinuous and continuous (Rhythm) Rapid and slow (Pace)	May require more than a decade of investment before financial returns are seen Characterized by evolving in a disordered, sporadic and dynamic manner	Typically short and predictable lead times Characterized by a ordered and less dynamic innovation process
Flexibility (vs stability) Process Structure Strategy	More flexible, integrative and improvisational models to manage emergence, based on simple rules Explore and develop parallel and heterogeneous less established 'weak ties' inside and outside the organization Probe, fast failure and learn rather	Operates with a set of routines and structures/procedures Exploit and enhance strong ties - work closely with existing customers and suppliers, in formal cross-functional teams Makes use of advanced project and risk management approaches linked

	than manage risk Strategy evolves through experimentation for market learning and creation	to predefined strategies and processes - stage gate monitoring Strategy, directions and goals are set at the beginning
Control (vs freedom) Roles Leadership	Need bottom up initiatives using informal relations and highly motivated, persistent champions in initial stages Need strong top management support and commitment for implementation in the later stages Feedback, reward and recognition system in place need to support risk taking and persistence	Need formal cross-functional teams from start Reward and recognition system in place need to support short goal achievement

Table 1. Identifying differences between radical and incremental innovation in relation to dichotomies in innovation management.

5. EMPIRICAL FINDINGS

To support the understanding on implications for the design of innovation measurement in the presence of the described dichotomies, companies with an explicit strategy to manage both radical and incremental innovation are used as an empirical illustration.

5.1 VOLVO AERO CORPORATION

Volvo Aero is a company in the aerospace industry developing components to aircraft engines and space rockets. The aerospace industry is a highly regulated industry, primarily with respect to safety and airworthiness criteria. Product development is largely contract-driven, which means that binding contracts are normally signed before development work starts and risk minimization is thus given higher priority than finding innovative new solutions during product development. Incremental innovation projects in partnership with the engine OEM (Original Equipment Manufacturer i.e. General Electric, Rolls-Royce or Pratt & Whitney) thus traditionally have dominated the product project portfolio along with a few more radical technology development projects.

Reduction of technical risks is an absolute requirement for a new product in the aerospace industry. However the risk taking is also related to the business model as the company recently is changing from being a provider of new technologies and products but to also provide advanced service solutions. The company is thus in need to understand how it can manage the different kinds of uncertainties resulting from the different type of project it aim to manage. Implementation of innovation performance measurement is by managers in the company believed to put more focus on innovation and inspire team members to strive for innovative results. However the current measurement system needs to be developed and be more comprehensive, include different factors that affect the innovation capability. But there is also a need for simple metrics so that the measurement can be performed often to show improvements.

5.2 ST JUDE MEDICAL

St Jude Medical is a Swedish site in an international medical technology company with 14000 employees' worldwide. Innovation is today required beyond the implementation of new technologies due to the need to manage complex relations between different medical conditions, technologies and actors in the health care supply chain in order to develop new product and product service systems. The directed change work aiming to develop innovation capabilities in the company is focused on improving the early phases of product development i.e. the front end of innovation along with the stimulation of idea generation in all departments. To support the coordination and enable learning from the experiences achieved in the experimentation of new ways to work, an innovation steering board was created along with the implementation of innovation measurement.

New measures were implemented with the purpose to signal the importance of also identify and develop radical innovation and to support the planned change work in order to understand what works and what seemed less feasible. The identification of new measures were performed by involving the teams in the organization and implemented along with the traditional R&D measures in use. This resulted in the selection of a broad range of measures adapted to the need for each group with some common for all. A number of challenges were identified related to a disagreement in what was required to be changed within different part in the company; going from proposing status quo to the need to provoke new mental models, behaviors and ways of working. Further, the strong link between innovation performance measurement and the existing recognition and reward system in place was revealed and found to be important to change if the measures also would act as a motivator and change tool.

5.3 ERICSSON

Ericsson is a leading company in telecommunication systems and has a long history of technology and business innovation in communications. Having an appropriate balance in exploitation and exploration activities is a clear and shared goal within the company which is also reflected in the Ericsson R&D organization referred to in this study. The organization is producing network management products adopted by various fixed and mobile telecommunication operators. Since these products are placed in a niche market there is a need to further strengthen the ability to innovate in parallel to continuously improve efficiency, speed and quality. The need to improve the decision process for selecting the right set of innovation projects to run in parallel is considered most important and particularly challenging due to the need to utilize internal resources efficient and since critical resources for innovation are few.

A new advanced forward-looking innovation performance management framework is under construction to support the innovation management. The goal is to provide management with leading indicators that can give the organization the agility to sense and respond to potential business opportunities and threats and to evaluate how radical and incremental innovation projects participate in the realization of current business strategies and goals. The information from the measurement system will be used to facilitate the decision making on a continuous and timely basis in order to identify the appropriate balancing and combination of resources to support both radical and incremental innovation. Such use requires the measurement system in terms of its ability to capture different types of internal and external information and to develop an understanding of the cause and effect relationships between the business goals and each innovation type.

6. ANALYSIS

From the literature and the empirical illustrations it is clear that the presence of dichotomies resulting from the management of radical and incremental innovation will have implications to the design and use of the performance measurement system in practice. Research literature is consistent in pointing to the importance of a performance measurement system to be aligned to the strategies of a company in order to provide a business value (Kaplan and Norton 1982; Micheli et al. 2010). For a company that has selected a dual strategy this will have an impact on the design and use of the measurement system since the dichotomies inherent in this strategy will create conflicting demands on what to measure. This will in turn require different types of data and information to be collected and analyzed simultaneously which provide an additional challenge to the problems already are facing companies that attempt to measure innovation (Smith 2005, Adams et al. 2006).

To identify what implication these dichotomies will have on the design and use of innovation measurement, the key dimension of each dichotomy was analyzed in relation to the measurement literature and the empirical illustrations.

All three case companies, from three various industries are all dealing with both incremental and radical innovation development. They all see the innovation performance measurement as an important tool to support and inspire innovation management in line with their business strategies and have initiated a development of such measurement systems although differing in level of ambition and procedures used.

Since measuring performance requires an understanding of both whether “the right thing” is created (i.e. effectiveness) and if “it is done rightly” (i.e. efficiency) (Bourne and Neely 2003; Lebas 1995) innovation as output and outcome vs. innovation as a process emerged as useful categories in the analysis process along with an analysis on implications on measurement based on dichotomies related to critical pre-conditions for innovation.

6.1 Innovation effectiveness – measuring innovation as output and outcome

The level of uncertainty can be argued to be the key difference between radical and incremental innovation; the former representing the highest level be it technical, market or project scope, resources or all uncertainty categories simultaneously. Performance measurement has a long tradition in industry, especially to measure innovation as an output

(number of patents, ideas generated etc.) and has proven to support management when it comes to control for goal fulfillment and learn if the operations of the company are in alignment to top management directions and objectives (Neely 2005). However, designing a valuable measurement system becomes a larger challenge when a company needs to explore into new knowledge fields requiring new ways to organize and work.

Radical innovations inherently will always contain high levels of market and environmental uncertainty why the number of market related measures need to be increased in contrast to incremental innovation. As a response to the high level of uncertainty, experimentation will dominate the development of radical innovations, and the generation of both physical and virtual prototypes and probes to learn about market and technology risks can thus act as a replacement to traditional measures, as shown in the study by Davila (2000). Managers need to allow for a broad range of effectiveness indicators of very different character in their data collection and analysis process i.e. from simple robust quantitative measures in use for known and familiar phenomenon to complex data in order to analyze weak signals and rapidly sporadic events and physical prototypes.

Since the level of uncertainty for a radical innovation will remain high even beyond its commercialization in contrast to incremental innovation, measures related to this stage need to be carefully considered and companies have been found to replace profitability with market growth for their radical innovation as a way to "protect" their radical innovation output from being withdrawn from the market place too early (O'Connor and DeMartino 2006).

Selecting the right ideas and projects that will bring most business value always provides a true challenge the more radical and novel these ideas and projects are to the company (Christensen et al. 2008). This challenge will be further accentuated when the company has the ambition to simultaneously manage a portfolio of both radical and incremental projects. The difference in character between these ideas and projects makes it hard to compare them why building skills in project portfolio management is a requirement in order to understand how to manage such mix of projects. However, existing portfolio tools and methods have been developed to support incremental innovation rather than radical which is reflected in how companies have a tendency to become biased towards incremental innovation due to high levels of uncertainties and risks and the long time before radical innovation bring a financial return (Christensen et al. 2008). Alternative ways to value essential different ideas are thus needed to balance the portfolio of projects (Corso and Pellegrini 2007).

Another common measure in use in companies that inevitably will favor incremental innovation is the criteria that ideas and projects need to be aligned to strategies and existing business models to be considered worth financing. Since radical innovation may or may not fit existing strategies and business models, this requires careful attention when designing the measurement system.

6.2 *Innovation Efficiency – measuring innovation as a process*

The significant differences in level of uncertainty and the different time perspectives inherently to radical and incremental innovation respectively leads to the need to adapt processes, structures and ways of working to support both types of innovations (McDermott and O'Connor 2002; Bessant 2008). The pressure on companies to provide short time profit will lead to an overly focus on process improvement rather than building complementary or new essential different processes and structures which favors the management of incremental

innovation (O'Connor and DeMartino 2006). This is reflected also in the design of the measurement systems which still are dominated by traditional financial and project management measures and indicators to monitor goal fulfillment, strategy alignment and process efficiency (Bourne and Neely 2003; Christensen et al. 2008). These measures have been developed for a long time and are familiar in how they should be interpreted and communicated in opposite for the kind of measures that would benefit radical innovation management. Since the process of radical innovation has an experimental character and is not fully understood the measurement system needs to be designed in order to inform about what actions and combination of resources that would be successful for the company. A broad range of measures need to be put in place to support the experimentation of new ways of working. This requires the identification of complementary measures and indicators as well as data collection and analysis processes to facilitate the more open-ended and improvisational radical innovation process. At the same time it needs to act as a tool for control in order to monitor and diagnose existing ways of working through the use of the traditional metrics to support the improvement and incremental innovation.

One additional feature for innovation efficiency that differs significantly between radical and incremental innovation and which will also have implications on the design of the measurement is that the former require the building of new relations inside and outside the company, preferably of informal and heterogonous character, whereas the latter need to deepen and improve existing relationships (McDermott and O´Connor 2002). Implications to the measurement system are a need to identify measure that can bring information about relations. Also, since measurement systems in general and R&D systems in particular tend to pay more attention to internal process measures at the expense of external (Brown and Swenson 1998) the management of both radical and incremental innovation requires a balance in the external/internal focus to support both.

A highly flexible and `generous´ measurement system, with different types of measures and indicators, allowing for a rapid exchange of one set of measures and yet provide the stability required to monitor an incremental development is thus needed. Since changing one element in the company's innovation system inevitably leads to a need to change others i.e. all elements are interlinked this needs to be taken in consideration when designing and using the measurement system i.e. changing one measure need taking all the others in consideration.

6.3 *Measuring Pre-Conditions for Innovation*

Research studies as well as international large –scale management consulting surveys show that creating an innovation culture is a key success factor for companies when managing their innovation effort (Tellis et al. 2009; Booz & Co 2011). In parallel performance measurement research has pointed to the importance for measurement to be aligned to the culture of a company culture in order to become a source for innovation and learning (Henri 2006; Chiesa et al. 2009).

Since radical and incremental to a large extent are nurtured by conflicting culture or climate factors which needs to be reflected in the reward and recognition system in a company this will have implications on the design of the measurement system accordingly; measures and indicators to support both set of values and norms need to be implemented. However, if the purpose behind the new measures, even though they are selected to support important aspects of radical innovation is not well-communicated and followed by the adaption of other systems

like the reward system in the organization, the study by Melnyk et al. (2010) shows how these can become contra-productive.

Radical innovation requires strong bottom-up commitment and involvement in the initiation and strong structured, top management support close to commercialization (O´Connor and DeMartino, 2006) whereas for incremental innovation the direction and objectives are set from start (Bessant 2005). This challenges the procedure for measure identification (Bourne and Neely 2003) where a switch between audit and need-driven procedures need to be used to facilitate different stages in the development of radical innovation in opposite to incremental innovation.

The implications on the design and use of innovation performance measurement emerging from the analysis are summarized in Table 2.

DIMENSION IN DICHOTOMIES	**ISSUE IN MEASUREMENT**
Uncertainty Technical Market Project scope Resource Strategic alignment	Radical innovation: • requires a higher number of market and external environmental measures than incremental • need to be measured on sales growth rather than profitability in the commercialization stage in contrast to incremental innovation • requires high amount of data from different sources compared to incremental • need to not be measured using strategic, operational and business model fit as a requirement why the opposite is needed for incremental Prototypes or probes may replace traditional project management measures in the development of radical innovation
Time Long and short (Length) Discontinuous and continuous (Rhythm) Rapid and slow (Pace)	Valuation and selection of idea and projects require different measures: ex. ROI, net present value (for incremental) vs. Opportunity cost (for radical) Radical need to be supported by measures that trace rapid and unexpected events and incremental measures that traces alignment to a predefined path.
Flexibility (vs. stability) Process Structure	Incremental innovation benefit from using the same measures for a long period of time More measures for external communication and for measuring relations needed for radical innovation Radical innovation: • requires a broad number of quantitative and qualitative

	measures that can easily be exchanged • requires measures to support strategy development i.e. what works and what does not why measures that control the alignment to goals and strategies are sufficient for incremental innovation.
Control (vs. freedom) Roles Leadership	Measure identification and implementation for radical innovation require both audit (bottom up) and need driven procedures (top down) why incremental innovation is supported by a need driven procedure alone. Measurements need to be aligned to and support both radical and incremental recognition and reward systems

Table 2. The implications on innovation performance measurement in relation to dichotomies in innovation management

7. CONCLUSION

The study clearly shows how dichotomies present in the companies with an explicit ambition to manage both radical and incremental innovation are generating a number of challenges when designing and using innovation performance measurement. The analysis of what implications the different innovation-related dichotomies put on the design and use of an innovation performance measurement system is found to be rather informative as they bring a fresh perspective on why measuring innovation remains a problematic area in today's companies. The dichotomies discussed in this paper are not claimed to be exhaustive, however we argue they focus on key elements that needs to be taken in consideration when designing a truly supportive innovation performance measurement.

This work presented in this paper is a first step in a research project that aims to develop a deeper understanding on how measurement can become a useful support in companies with an explicit ambition to manage both radical and incremental innovation. It provides the theoretical basis for further investigations and development in practice and theory.

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