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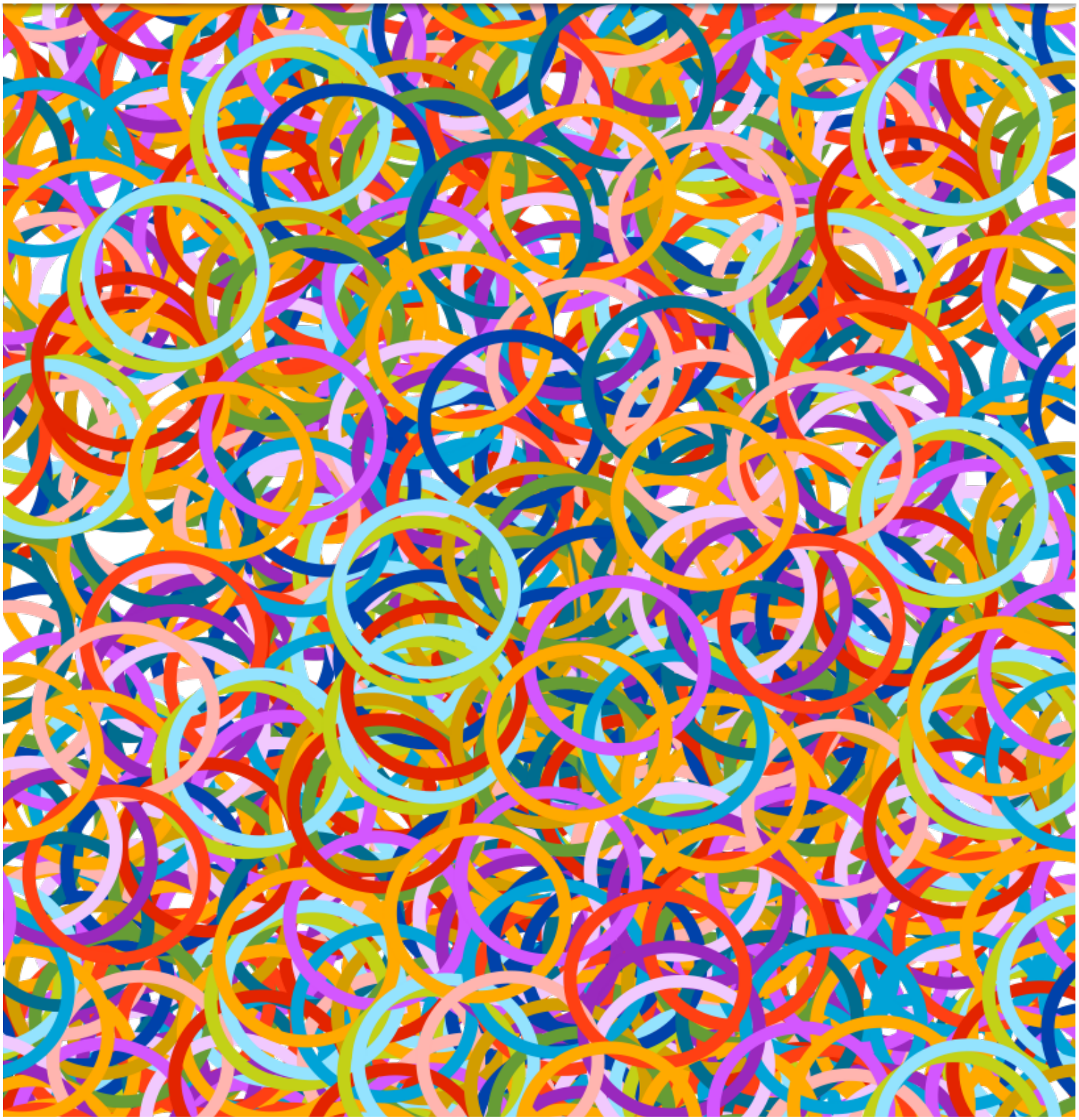

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Editorial

> *"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too."*
>
> John F. Kennedy September 12, 1962

Innovation is a journey that is full of challenges. It is demanding, but we need to keep inspirational aspects in mind, such as the ones President Kennedy expressed in his predestinated "sticky" (Heath and Heath, 2007) speech in 1962 about sending a man to the moon. Since the seminal works of Schumpeter (1934), innovation has been widely acknowledged as a key driver of competitiveness, economic growth and welfare. There is a wealth of empirical evidence supporting a positive relationship between innovation and firm-level performance in the academic literature (e.g. Crépon et al., 1998; Griffith et al., 2006; Lööf and Heshmati, 2002). At firm level, innovation has long been recognized as a competitive advantage and a key driver of economic performance (Schumpeter, 1934). Innovation also lies at the very heart of policy mechanisms to achieve a smart, inclusive and sustainable growth in economies, as envisioned by the Europe 2020 strategy (European Commission, 2013).

'Innovate or die!', 'The cure for Apple is not cost-cutting. The cure for Apple is to innovate its way out of its current predicament' (by Steve Jobs, Forbes 2012), Are they the latest buzzwords and sentences on innovation matters? Another ephemeral managerial fad? Old wine in new bottles? Or perhaps, just perhaps, a fundamental means of survival and success for modern day corporations? Given the amount of effort that has been devoted to the innovation management topic by academics, practitioners and policy makers alike, we argue that it is worthwhile to take a deep, objective and dispassionate look at the role of innovation management in sustained competitive advantage. In our views, innovation is not an option or an exception but has now become the norm and a must for public and private entities. Yet, open issues relating to its management, its antecedents, its impact, its benefits, and its challenges are waiting to be explored. Let's start by unveiling our definition of innovation.

Our view on innovation departs from the commonly adopted definition provided by the OECD (2005), which stresses the different types of innovation as well as their degree of novelty. We support that the different innovation types are more and more closely intertwined, with the lack of relevance of e.g. the distinction between goods and services, as those are being simultaneously offered as innovative bundles. Along the same lines, service and process innovations are hardly dissociable (de Jong et al., 2003; Toivonen and Tuominen, 2009), especially in the context of service economies. Thus, we consider innovation as any invention or idea that has a potential to bring value, for individuals, firms, organizations or societies. We perceive value in a multifaceted way, so as to embrace both economic and intangible aspects. We also support that innovation is both a journey, with its hurdles, uncertainties, risks,

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successes and failures, and an outcome. The Journal therefore welcomes submissions related to innovations in terms of technological developments, novel offerings, new forms of organizations, innovative business models, social innovations, to name a few.

Innovation is a laboratory for applied creativity where the development of innovative projects and the exploration of new directions in different disciplines are dynamically perceived. We are convinced that innovation enables a more conscious perception of place and its characteristics; it is an experimental space in which design methods can be used to examine and interrogate ideas, forms, structures, dreams and visions. Innovation is about transgressing boundaries of multiple disciplines in view of developing novelties or improving existing offerings, methods and processes while taking into account numerous dimensions and angles. It is also about opening new perspectives on the world of tomorrow. Furthermore, innovation is also a mindset, which has to be nurtured and cultivated. The currently turbulent environment renders innovation even more challenging, yet necessary, to reach the competitive edge and maintain sustainable advantage. The successful ability to innovate requires a multidisciplinary attitude towards understanding, designing and implementing an overarching innovation strategy. Innovation requires the opening of new research pathways by encouraging and giving freedom of expression to voices that see innovation from an alternative lens and prism. Innovation as a multifaceted phenomenon existing in every scope and lead of life requires simultaneously diversity, an open-minded attitude and a multi-level approach.

We posit that adopting a multidisciplinary approach is achieved by combining both vertical and horizontal perspectives so as to embrace innovation management with an overarching perspective. Our vision is that the vertical perspective is grounded in natural or hard core sciences, such as physics, medicine, engineering and chemistry. Inventions usually frequently emanate from these disciplines. But innovation goes beyond invention and we support that it requires the involvement of a horizontal dimension, which covers the processes of idea generation, identification and selection of opportunities, commercialization, economic valuation and impact assessment. All these processes require the involvement of social sciences, business, economics, marketing and other so-called soft disciplines. In other terms, the vertical and horizontal perspectives are indissociable and complementary, and both are needed to create value, for individuals, firms, nations.

To the best of our knowledge, the extant range of journals currently available adopt a rather superficial approach to multidisciplinarity, usually restricting their scope either to natural or social sciences. Our aim is to reach this true multidisciplinary approach by combining these so-called *hard* and *soft* sciences.

The relationship between traditional academic publishing and general approval/validation of open-access journals appears to have changed in the last decade. Drivers of this change are multifold: rapid increase in number of open access journals, new and different business models of publishing, demand for availability and accessibility for both academic citations and readership of practitioners for impact, and finally, the takeoff of open innovation paradigm. As it applies to companies, academia may face the dilemma “If you are not open, you are closed!” (Torkkeli, 2012), although this requires some nuance and the adoption of a carefully

thought and balanced contingent strategy.

As we are living in an era where innovation management is a must for every organization, at the same time the way how we share knowledge about innovation may need to be renewed. Publishing business is changing, and there is a clear discontinuity happening among traditional journals, with open access strategy booming. Presumably, the open access of the journal answers the contemporary demand towards the shift from a closed to an open environment and the destruction of silos and boundaries in research. The flow and availability of knowledge encourages the adoption of innovative practices and the mental preparation for becoming the driver of change and creativity, both inherent elements of innovation. But the real questions at the bottom line are whether traditional publishing shifting to an open access business model embodies really and truly open access?

There is increasing pressure from governments and funding bodies to make the results of taxpayers' money invested into research freely and openly accessible. Research Councils UK and the White House Office of Science and Technology Policy recently took steps in this direction as reported by the Economist in May 2013.

Large publishing houses have started a shift in their business models, where authors actually pay to get their papers published and "openly" accessible with a limited, if any, embargo. To some extent, this strategy competes with the booming open access industry. Nevertheless, the reputation and credibility of some open access journals have been largely debated and thus simultaneously jeopardize the willingness of researchers to publish in these outlets and universities/official bodies to recognize these journals as acceptable for publishing research outcomes. Some of the most frequently raised concerns relate to the extremely fast and rather superficial review process, which is considered as one of the main gatekeeper of publication quality. Our strategy is to combine the best of both worlds (i.e. lengthy but thorough peer-review process and speed of full open access journals), thus delivering high quality publications and insights, ensuring a high level of quality of the review process, and allowing publications to be freely and openly available. Our large editorial board and associate editorial team, consisting of over 100 experts, and covering the spectrum of research areas and methods, represent one of our key assets to guarantee a smooth, yet demanding and extensive, review process. Such filtering mechanisms aim at ensuring that speed is not favored to the detriment of quality and that we can simultaneously apply highly selective criteria for publication within a reasonable timeframe.

The philosophy of the Journal of Innovation Management adopts a multidisciplinary perspective on innovation. In doing this, it fills this existing gap by hosting visionary and eloquent research streams enabling the understanding of innovation, appreciating differentiation and striving for academic excellence and insights for practice. The Journal aims at paving new ways of fostering innovation and at bridging the gaps between the different communities involved in the definition of innovation policies, in the analysis of the innovation process and its multiple outcomes, and in its implementation in public and private entities. It brings the reality of innovation at hand by fostering a philosophy of true innovation management by encapsulating insights, valuable experiences and theoretical streams. With this initiative, we create a new Blue Ocean (Kim and Mauborgne, 2005) and aim at reconfiguring the publishing "arena" by combining the best of both worlds while adopting a visionary

approach on both innovation, its management and publishing practices.

Furthermore, the Journal of Innovation Management aims at hosting the debate for innovation, whatever form and facet it takes, and its management. Particular attention is paid to the multidisciplinary nature of the innovation, thus embracing both its technological features and its managerial process. Issues of the journal will typically contain academic papers, letters from industry thought leaders, academics, and policy makers, book reviews and commentaries. Four issues per year will be released, and some special issues are also foreseen, so as to concentrate on dedicated themes, which will be addressed from multiple angles. Our ultimate aims are to foster cross fertilization across disciplines, to bridge gaps between academia, practice and policy making, to raise awareness on innovation, its challenges and its impact as well as to shape new reflections and thoughts on innovation, and its management. We aim at broad scope of readership in innovation. The Journal of Innovation Management is a platform for exchanging ideas in both horizontal and vertical dimensions of innovation management. The idea is to publish topical research works, practitioners' insights and case studies on innovation with multidisciplinary flavor.

This first issue reflects the philosophy and the overall aim of the Journal of Innovation Management, which is to host the debate on innovation challenges, as perceived by academics, thought leaders and policy makers, from a multidisciplinary perspective.

In his provocative and topical academic letter, Tribolet restates the role of academic institutions in stimulating, nurturing and bringing to maturation stage the intrinsic capabilities of individuals to engage into an innovation journey.

The industry letter by Deutsch and Baby provides practical insights on how an open and collaborative approach to problem solving can leverage innovation capabilities within and across firms, with illustrations from a firm belonging to the pulp and paper industry and a series of events held in Canada.

Letters are followed by a selection of eight academic papers, which originate from various disciplines and cover a wide range of methods and empirical settings. In the realms of marketing and organizational innovations, Hulten scrutinizes how the use of visual and auditory cues acts as stimulus for shoppers' approach and touching behavior at the point of purchase in the retail industry, applying a carefully designed experimental and observational method. Pace's contribution also revolves around customer behavior, and explores how customers actually shape an innovation. A key contribution of the paper resides in the original empirical setting under scrutiny, Google Glass®. Kliewe et al. astutely combine innovation and change management to unveil the key elements inducing a sustainable innovation environment in a large professional services firm. Their case study uncovers the strong influence of communication, involvement of company leaders and adequate incentive mechanisms on innovation culture. Cultures for sustainable innovation are also the core focus of Prud'homme van Reine's paper, which develops a dynamic framework to assess innovation culture in two regions, thus contributing to the regional innovation systems literature, from a multidisciplinary perspective. Another critical issue in the growth of firms is their internationalization process. Qi's conceptual contribution focuses on the determinants of outward FDI entry mode choice, and more specifically discusses the role of network and ownership in the behavior of Chinese firms. In their exploratory

qualitative work, Durst et al. shed light on the knowledge creation process in an industry that is traditionally perceived as non innovative. Their study on the construction sector in Germany provides valuable insights on the behavior of managers toward internal and external sources of knowledge. In their empirical study of SMEs, Van Auken and Carraher uncover how some characteristics of entrepreneurs affect their propensity to prepare and use financial statements for informed decision-making. The last contribution of this first issue, from Tanik, emerges from computer sciences and elaborates a comprehensive architectural framework to improve the design process of cyber-physical systems, which is further implemented in a single case study in view of deriving a toolset using knowledge-based engineering systems.

As described above, the selected papers in this first issue depict the variety and the diversity of the contributions expected in the Journal of Innovation Management. This diversity is captured by the multiple and various methods, techniques, perspectives, empirical settings, theories mobilized, and epistemological approaches. In essence, this first issue brings upfront the true necessity and value of a multidisciplinary approach on innovation.

Bringing this Journal to live has been a tremendously challenging and rewarding journey. And yet, it is only the beginning. We sincerely hope you will join us in the forthcoming stages of this journey, and we look forward to fruitful multidisciplinary experiences together!

With such a wide range of people covering globally both horizontal and vertical aspects of innovation management, we cannot conclude without sincerely expressing our gratitude and thanks to the Advisory Board, Editorial Board and Associate Editors of their open-minded attitude towards the new journal – let the journey begin!

Innovatively yours,

João José Pinto Ferreira, Anne-Laure Mention, Marko Torkkeli

Editors

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Letter from Academia

Educating the educators to innovate: the need to reinvent academia´s mission and to reengineer their basic tool: the Educator

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Abstract. Innovating is an attitude towards the world. For humanity to improve its capabilities to innovate, then innovation, as an individual capability with social value, must be nurtured since birth, in every human being, along with the full toolset of values, such as liberty, responsibility, solidarity, compassion, honesty, among others. A foundation for the acquisition and maturation of the innovation attitudes in an individual lay on its basic drive to question the world, to understand, i.e. model it, and in such process, to identify perplexities that confront him as problems to be solved or opportunities to be addressed. I consider the development and maturation of these capabilities in each individual an essential responsibility of academic institutions. To adopt encompassing processes for providing learning environments, for the students to acquire and develop innovation capabilities, Academic Institutions need to refurbish their production tool set, so that it acquires inherent innovation capabilities in all the dimensions of the academic activities. This is perhaps the biggest challenge today for these Institutions, because it requires massive reprogramming of the Professors mindsets and practices.

Keywords. Innovation, Youth, Professors, Academia, Values, Capabilities, Learning Environments.

1 Innovating as an attitude

As an academic member of the novel Journal of Innovation Management, The International Journal on Multidisciplinary Approaches on Innovation, I bring forward to this first issue, some of the lessons life has taught me on the fundamental role education, and in particular, the role of the Academy, may and should play in the inculcation of innovation attitudes and practices in youth.

First of all, innovating is an attitude towards the world.

An human being manages his life by continuously balancing the minimization of risks for himself, therefore, securing a stable and predictable environment under his control, with the maximization of its differentiation from others, by searching value added, realizable opportunities, with potentially high future gains.

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This balancing dynamics evolves since birth, and is strongly conditioned by all the experiences lived by each individual as time goes by. The role of family and the social institutional ecosystem that surrounds a child in their first years is, we all know, of tremendous relevance in the configuration of the values, the attitudes, the relational and emotional skills, of the future adult. In particular, the pedagogic models adopted to frame the child´s education and the practices of action that the child experiences at this early stage, if not properly aligned with the acquisition and development of positive values, attitudes and skills, greatly impairs or even prevents their maturation in adulthood.

And this starts with the family unit, one should never forget! And it goes on through kindergarten, K-12, the scouts, the sports clubs, and so on.

So, the systemic design, operation and monitoring of the social and educational processes in the various institutional frameworks within which the growth of the youngsters flow in society should be a subject of major consideration in the construction of the future of each and all of us.

For humanity to improve its capabilities to innovate, then innovation, as an individual capability with social value, must be nurtured since birth, in every human being, along with the full toolset of values, such as liberty, responsibility, solidarity, compassion, honesty, among others.

Unfortunately we must recognize that often the “early-ages ecosystems” surrounding the child not only is not tuned to these goals, but often provides its antithesis, repressing innovative attitudes, rewarding conformity and egotism, repressing individuality, and nurturing the very anti-social values that are so widespread in our societies today.

2 The role of academic institutions

The role of academic institutions in providing the adequate environment and learning experiences for the proper maturation of each individual is, obviously, central in the configuration of the social attitudes towards innovation and the provisioning of individual skills best fit to actually innovate.

I strongly believe in the processes and the environments that pursue learning by doing, followed, of course, by reflexive actions, involving conceptual abstraction, theory formulation and knowledge building stages, which enable higher levels of individual and collective innovation initiatives, in real operational contexts.

Academic institutions should be, by definition, boot camp grounds for innovation, getting young people ready for the big battle of active life, challenging them to be Architects of the Future.

3 Modeling the world, questioning reality, innovating by acting, learning by doing

A foundation for the acquisition and maturation of the innovation attitudes in an

individual lay on its basic drive to question the world, to understand, i.e. model it, and in such process, to identify perplexities that confront him as problems to be solved or opportunities to be addressed.

I consider the development and maturation of these capabilities in each individual an essential responsibility of academic institutions. Providing learning contexts where the youth is faced with situational modeling and problem formulation is much more relevant than training him on how to present the "right" answer to a given problem.

And it is in this context that the development of the individual capabilities for innovation may and should happen. One learns how to innovate, by innovating and, in a structured and reflexive process, learning from what one has done.

4 Scouting and discovering, formulating and solving, developing and deploying, using and evaluating, improving and redesigning

Fostering innovating attitudes in an individual, framing innovative actions in solid, sustainable organizational processes and in societal frameworks are essential aspects of the "academic mission list". Acquiring these individual "actionable capabilities" should also be part of the learning goals of any youth as it progresses along its academic education.

In my view, the primary intent of involving students in research and development activities is precisely to provide an adequate context for the acquisition of these actionable capabilities. The effective outcomes from such research should be seen, in terms of the essence of the student´s education, secondary, collateral results. Unfortunately, the emphasis is often put on these latter secondary outputs, rather than on the first, truly essential results. This serves the purpose of the supervisors, and their research interests, but not of the educator that should always live inside the professor and certainly not of the society that entrusted him with the educational responsibility of the youth.

5 Educating the educators to innovate: the need to reinvent academia´s mission and to reengineer their basic tool: the Educator

Academic institutions constitute a key institutional asset of Humanity. They are proud of their knowhow, they are fiercely independent; they follow strict rules of excellence.

Their core "machine tools" for the production of their outputs – highly educated professionals – are their Teaching Staff, the Professors.

To adopt encompassing processes for providing learning environments, for the students to acquire and develop innovation capabilities, Academic Institutions need to refurbish their production tool set, so that it acquires inherent innovation capabilities in all the dimensions of the academic activities.

This is perhaps the biggest challenge today for these Institutions, because it requires

massive reprogramming of the Professors mindsets and practices. The type of challenge has occurred in the past regarding research, and the academic world was able to address it quite adequately.

In this XXI century, the Innovation Mindset challenge is now in the forefront of the transformations required to happen in the Academic Ecosystem.

I hope this new Journal provides a serious and credible Forum to address this challenge and serves to promote and disseminate the best practices in operation today, so as to speed up this fundamental transformation that is required to happen in the Academic World.

Letter from Industry

Solving complex problems: the Seeking Solutions approach

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Abstract. This article describes the Seeking Solutions approach a problem solving conference using open innovation. The Seeking Solutions process consists of four steps: a call for problems, problem selection, problem broadcast, and a collaborative event. This approach has been successfully used for several events since 2010 with concrete results and real impacts. By mixing open innovation and collaboration, the Seeking Solutions approach brings a new way to solve complex problems and generate real innovation.

Keywords. Local Open Innovation, Open Innovation, Crowdsourcing, Broadcast of Search, Collaboration, Seeking Solutions.

1 Introduction

Companies have to innovate always quicker in order to remain sustainable and profitable in this fast changing world. Innovation is very often wrongly associated only with invention or development of a new technology, but in order to successfully create value in the market, companies have to take into account social, environmental, political, human and economic factors. In fact innovation becomes a question of complex problem solving.

There are a lot of processes and best practices to successfully address product development and marketing but these processes do not take into account the fact that you may not have the best resources in your own company to achieve success. Open Innovation is a new way to overcome this problem but it still does not address the question of growing complexity of problem solving.

We propose a new way to enable innovation in a complex world: the Seeking Solutions approach. The approach is based a combination of open innovation and collaboration. In this paper we will shortly present the methodology and give some examples of companies that tried it and got great and concrete results.

2 Seeking solutions

The Seeking Solutions approach is a problem solving conference. It consists in a 4-step process:

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1. **Call for problems**:
   The promoter of the event asks his community to submit complex problems that defy the standard analyses of his experts in the field. This usually takes place several months prior to the event itself.
2. **Formulate selected problems**:
   Once the problems have been submitted, we help the promoter to select those most likely to garner interest at the event and to formulate them so that they can be more easily shared. An expert of the problem's domain, called an ambassador in our case, is put in contact with the solution seeker. Just by asking some basic questions, the ambassador is able to help the solution seeker further define the problem and ensure that the description that will ultimately be posted on a web-based platform is sufficiently clear and broad.
3. **Disseminate to a wider community – Problem broadcast**
   We disseminate the problems to be addressed to a vast range of specialists in a variety of fields. They can provide a different outlook on the problems raised, ask preparatory questions and participate in the event. Broadcast is done through a web-based platform including as much information as possible, such as figures, references, or details of failed solutions.
   Two strategies are employed during the problem-broadcast step. A general broadcasting approach ensures that everyone who thinks they could help has the opportunity to participate. A targeted broadcast to specialists based on expectations about what type of expertise might be relevant to a particular problem is also used in parallel.
4. **Seeking solutions events**
   The last step is what differentiates the Seeking Solutions approach from other open innovation techniques, because it involves a real event where non-virtual collaboration arises. Solution seekers and problem solvers come together during a full-day session to focus on the selected problems. Careful preparation is required to ensure maximum output from the event. The collaboration process is divided into three phases: i) divergence, ii) exploration, and iii) convergence. Our facilitation methods allow for significant and creative interaction with experts who are normally not part of the same networks, and take full advantage of the "cross-pollination" of brainpower effect.

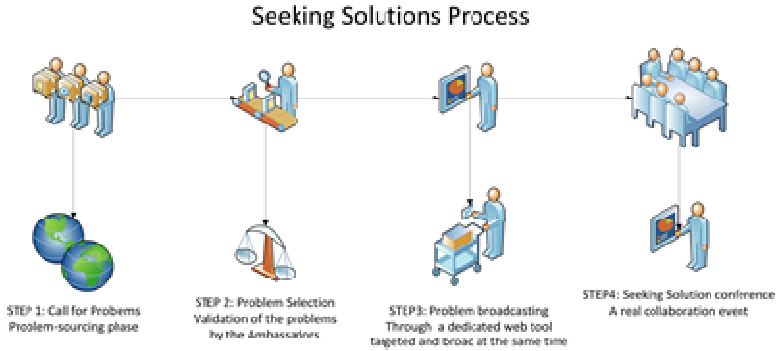

Fig. 1. The Seeking solutions process

This approach that seems very simple and straight forward has been developed over the years and requires a lot of details that need to be taken into account in order to get successful outcomes. In order to help individual companies, cities, conference organizers, industrial clusters or economic development organizations to organize successful Seeking Solutions events, we have created a company called En Mode Solutions (EMS). EMS provides all the support to put the approach in place and continues to improve the methodology.

3 Some examples

Several events have taken place since the emergence of the approach in 2010. In the following paragraphs we will describe some examples of successes obtained during these different events.

3.1 The Kruger case study

The first event took place in December 2010 as a regional problem solving conference in Quebec and was called Quebec Seeks Solutions (QMS). Ten problems were submitted by nine industrial companies and 175 persons participated to this event. Two major partners helped this event to be a success: *IDTEQ*, a group of five applied R&D centers and *Quebec International*, the local economic development organization.

During this event Kruger, a paper mill company, submitted the following problem: they needed to find innovative applications to use their new coating machine in their Trois Rivières' plant or else they would be forced to close the plant.

Natural problem solvers would have been found within the paper industry, but the innovative solution actually came from a researcher in the agro-environmental domain who proposed that Kruger should produce paper tarpaulins with embedded fertilizer to preserve soil humidity and fertilize the crops. In fact the use of mulch in horticultural production is a widespread practice in agriculture. However, the use of plastic mulch raises a number of environmental problems since such plastic films are too dirty to be recovered and are sent to landfills. Therefore developing effective agriculture mulch made from recycled paper could overcome this environmental problem and offer as well the pulp industry new markets for their cellulose products.

Fig. 2. Paper tarpaulin instead of plastic

This solution was unobvious and highlighted the importance of "outsider" input into the innovation process that the seeking solutions approach enables. As a result of this idea of new product two applied R&D centres (IRDA and FPInnovations) proposed a feasibility study to Kruger, developed a tarpaulin, and began testing it less than eight months after the event. Following this preliminary feasibility study, a second phase of research and testing in real conditions involving IRDA, FPInnovations, Kruger, Tembec Resolute Forest Products and Dubois Agrinovations, was proposed and the Province of Quebec has decided to fund it with a half-million-dollar joint project that is currently ongoing.

3.2 QMS Second edition examples

Thanks to the success of the first edition, QMS came back in May 2012. Nine solution-seeking companies and 162 problem solvers participated in the two-day event. Here are two examples from this second edition that have led to great benefits for the seeking companies.

Fourrures Grenier is a SME producing fur boots. They had a problem in their manufacturing process since years because of the rigidity of the sole they used. During the event they not only discovered a solution to their manufacturing problem but also a new partner from the composite industry that now produces the sole. The new sole is more flexible and therefore eliminates the manufacturing problem they had. It is also produced at lower costs and with a local partner avoiding cultural, language and contractual complications they had in the past. For this SME, participating to QMS made a huge difference in their potential to grow and to increase productivity.

Fig. 3. Solving a fur boots problem

GL&V Canada, did submit a problem of equal distribution of the output flow of up to 100 hoses for a central distribution system. These complex systems are used in the paper mill industry. Investigation of non-uniform flows requires shutting down the whole system for several days leading to huge production uptime losses. The solution

found after the event is a very simple and low cost method that avoids to shutdown the whole system. The few hundred dollars solution helps saving millions in maintenance cost. The solution came once again from the agro-environmental industry and GL&V would never have found this solution without the serendipity that the Seeking Solutions approach enables. They are using this new solution since January 2013 and generate an excellent ROI.

3.3 Next events

In the following months several other events will take place. The first one in called Polymers Seeks Solutions and is an event organized specifically for this sectorial cluster. The Innovation Polymères Consortium is the promoter and En Mode Solutions implements it. Six problems related to that industry have been submitted and here is one example. Bombardier Produits Récréatifs (BRP) has submitted a problem around the formation of porosity in a gelcoat projected robotically on a mold. The porosity is a major aesthetic defect that the company hasn't succeeded in eliminating after about 6 months of experimental work and they are now seeking for solutions in an open innovation mode. The event will take place September 26th in Saint-Jean-sur-Richelieu, Canada.

The 3rd edition of Quebec seeks solutions will take place in November and 8 problems will be addressed. The problems have not been broadcasted up to now; the ambassadors are in the process of defining them with the seeking companies. Two other events in the Mining and in the Health industry will also take place before the end of 2013.

The increasing number of events and the results already obtained show that the approach is responding to a need that was not filled up to now.

4 Conclusion

Open innovation and open problem solving approaches require a change of mindset to reach its full potential. A change of mindset most often requires a pain or an enormous challenge to work it's way. The current economical context is a good enabler I would think! Because statu quo is not an answer for anyone, in any type of industry and in any country right now!

Many problems that the companies are facing today are complex because they mix technical, environmental, social, and political issues. To face this growing complexity, classical problem-solving methodologies are no longer appropriate. The Seeking Solutions approach has the potential to address the complex challenges of the next decade and we believe that it can help to migrate from a collection of intelligences to a real collective intelligence. The next step is to encourage more and more companies to try local open innovation and to convince local governments to support this movement.

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Sensory cues as in-store innovations: Their impact on shopper approaches and touch behaviour

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Abstract. What impact do visual and auditory sensory cues as in-store innovations exert on shopper's approach and touch behaviour at point-of-purchase in a retail setting? The presented research depicts shopper's behavioral response in relation to the influence of sensory cues for an appealing and attracting store atmosphere and design. The author presents a review of theoretically relevant work and a field study through experimental and observational methods in examining the impact of visual and auditory sensory cues as in-store innovations in a retail setting. In the reported study, the author finds significant behavioral impact of introducing visual and auditory sensory cues on shopper's approach and touch behaviour. The findings offer guidelines for retail managers in applying sensory cues as retailing innovations in relation to the human senses in creating successful sensory experiences at point-of-purchase.

Keywords. In-store innovations, retailing, sensory cues, store atmosphere, point-of-purchase

1 Introduction

Human senses, consumer experiences and sensations are considered in emerging marketing paradigms as a major subphenomenon (Achrol and Kotler, 2012). It is obvious that consumers as shoppers experience brands, products and servicescapes through vision, sound, smell, touch and taste, which highlights the significance of sensory cues and stimuli. It has been suggested that the use of subconscious sensory triggers in sensory marketing might be an efficient way to engage consumers and influence their behaviour and perceptions (Krishna, 2011).

Through research, it has long been evident that retail atmospherics as environmental stimuli and sensory cues affect shopper behavior in retail settings (Bettman et al., 2008; Hulten, 2012). Adding such stimuli to a retail environment can result in an emotional response leading to a willingness to approach/avoid a product (Russell and Mehrabian, 1978). This underlines the importance of investigating how different stimuli can affect consumer behavior (Sweeney and Wyber, 2002). Moreover, retailers may earn positive returns through offering an exciting shopping environment (Kaltcheva and Weitz, 2006).

Acknowledging that retail atmospherics are of a sensorial nature, the human senses have been recognized as major channels through which a retail environment is experienced (Kotler, 1974). Despite this recognition, the human senses and their impact on shopper behaviour have been mostly neglected in the marketing and

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retailing literature, although some empirical studies do reveal the significance of the senses of sight (Turley and Milliman, 2000), sound (Kellaris et al., 1993; Yalch and Spangenberg, 1990), smell (Bone and Ellen, 1999) and touch (Citrin et al., 2003; Peck and Shu, 2009).

Moreover, the question of how sensory cues in the form of in-store innovations, might impact on shopper behaviour, remains unanswered in the literature. As an object, idea or practice innovation may be perceived as positive by an individual or any other party concerning products, services, processes or any social system (Rogers, 1995; Schumpeter, 1934). Marketing innovation, in its many and varied forms, is seen as critical to customer loyalty and company success (Reichheld, 1996). It has been proposed that innovation should be a fundamental means by which marketers retain customers, emphasizing its importance for brand experiences derived from products and services. In business-to-consumer relationships, the innovation-customer interface is often neglected by producers and retailers as a means in enhancing consumer-based brand equity (Flint, 2006).

Especially in retailing, innovations are a common phenomenon which range from changes in business models, new concepts and ideas for global brands, as well as the introduction of new store formats and technologies. They support the pursuit of growth in mature and emerging markets (Shankar and Yadav, 2011). In shopper marketing, innovations are regarded as a way to enhance brand equity in the long run and are related to manufacturer and retailer innovations.

It has also been suggested that innovations in shopper marketing should be strategic or tactical. These include innovations in store atmospherics and design, related to such areas as shopper-centric store layout and design, as well as customized sensory experiences (Shankar et al., 2011). In this study, I define in-store innovations as "the application of sensory cues that intentionally draw shoppers attention to a brand and impact on shopper behaviour at the point-of-purchase".

The aim of the paper is to analyse how the deliberate application of sensory cues, as in the form of in-store innovations, could be seen as an appropriate means for retailers to draw shopper attention to a certain brand or product category in a retail context. Nevertheless, the application of sensory cues as in-store innovations has rarely been investigated in order to understand its influence on shopper attention and behaviour.

The paper is structured as follows. Firstly, the theoretical framework, research model and hypotheses are presented. Secondly, the methodology for the investigation is discussed and thirdly, the results are presented, followed by an analysis and discussion of the application of sensory cues as in-store innovations. Finally, the theoretical and managerial implications, as well as avenues for future research are considered.

2 Theoretical framework

The question of how sensory cues as retail in-store innovations could lay the ground for sensory experiences and sensations, is unanswered in contemporary research. This

is the case, despite the consensus on the importance of creating a pleasant and inspiring store atmosphere through attractive and facilitating sensory stimuli (Noad and Rogers, 2008; Soars, 2009). It is obvious that when shoppers visit a store, consider its assortment and investigate point-of-purchase for a certain brand or product category, a sensory consumption experience is taking place. The presented experimental research builds upon the experiential perspective of consumption experiences in terms of feelings, fantasies and fun (Holbrook and Hirschmann, 1982), as well as shopping and consumption as an entertainment experience (Moss, 2007).

2.1 Sensory cues

The sense of sight

Vision is the most dominant sensory system and most humans rely to a great extent on visible and tangible sensory cues that create attention for certain objects and products in the environment (Schiffman, 2001).

Research has documented that visual stimuli impact on consumer behaviour when it comes to judgments and purchase decisions related to product choice, purchase quantity or consumption (Krishna, 2008). Brand logos, colours, graphics, names, packages and product design are examples of visual stimuli that could be part of any branding strategy. Moreover, it has been shown that visual stimuli are more important in the absence of verbal material about a product. The reason is that the stimuli provide a quality perception, creating strong associations with a brand, and the use of graphic information might make it easier to create attention around a product (Henderson et al., 2003). This is especially so in a competitive clutter, where a positive influence on consumer judgment and purchase decision might result in a possible purchase decision (Kahn and Deng, 2010).

Studies have also confirmed that consumers may be either positively or negatively affected by visual stimuli without having access to other information. The use of graphics can enhance an aesthetic response to a certain product (Kahn and Deng, 2010) and visual stimuli may create an emotional response, besides drawing attention.

A common opinion is also that cognitive as well as non-cognitive reactions are based on visual stimuli, such as product design in relation to aesthetics (Hoegg and Alba, 2010). It is also evident that a human's product preference is based upon product design, that is, form or layout, instead of its functionality or brand name. Moreover, the form of a product creates an affective response, but the quality is related to cognitive evaluation.

It has been suggested that an unattractive product design might result in people searching for, expecting and detecting problems, as well as observing details instead of ignoring small problems. A visually attractive product design may enhance creativity in problem solving, as well as having an impact on mood (Norman, 2004). Altogether, design as visual sensory stimuli, might influence shopper approach and touch behaviour at the point-of-purchase.

In addition, studies have confirmed the significant effects of colour on individual affective and cognitive evaluations of products and store environments. Colour has been emphasized as an important visual stimulus and it is through colour that the sense of sight allows us to detect a store environment. In making a colour more

intense or through the contrast of colours, it becomes possible for an object or a product to be more conspicuous among other sensory distractions (Shiffman, 2001).

It is evident from research that people's emotions and feelings are influenced by colour, which in turn impacts on how active consumers will be and how they evaluate products (Babin et al., 2003). For that reason, the choice of colour is significant in a store environment or for the display of a product in creating attention, but especially with regard to what feelings could be evoked towards a brand (Gorn et al., 1997).

A general opinion is that cultural differences might explain how different colours influence consumer affections. It is evident that blue and red are two colours that affect people differently. Among the two colours, blue is often the most preferred, because it is perceived as more relaxing than red, which creates arousal (Chattopadhyay et al., 2010).

The sense of sound

In the literature, sound has long been recognized as a significant stimulus with positive effects on consumer mood, preferences and behavior (Alpert et al., 2005). In this regard, music is identified as the "shorthand of emotions" in creating emotional responses (Kellaris and Kent, 2001). Accordingly, music is suggested as touching consumers in different ways, so that perception and mood towards a certain brand might be influenced by music (Gorn et al., 1997).

There are many sources of sound, in the environment around us wanted and unwanted. Humans seem to experience sound highly individually and react in different ways to the same sound (Rossing et al., 2002). Music is not the only sound in the environment and especially noise creates physiological as well as psychological effects, which impact on communication.

Research has focused on music for decades examining the effects on consumer affections and behaviour in relation to different objects or products. The human voice has not received the same attention among researchers (Peck and Childers, 2008). However, it is evident from research that the human voice impacts on consumer behaviour in terms of its persuasive power, and its pitch and speed can enhance an advertising message.

The human voice is different from other sounds in the environment, standing out in its own personal way. For that reason, the human voice can reinforce emotions and feelings, affecting the actual message through for example: coughing, laughing, speech, yawning etc. (Schiffman, 2001). It has been argued that a language need not be heard, because the sound of a voice might create the feeling of a message being perceived and interpreted, even though the real meaning itself could be hard to understand. It is also possible to give human voice different characteristics including flat, hollow, robust and sharp types of voices (Sonnenschein, 2001).

2.2 Shopper approach behaviour

The interplay between store environment and shopper behaviour is reflected in the stimulus-organism-response (S-O-R) paradigm, following Mehrabian and Russell's (1978) approach/avoidance model of environmental psychology. It is suggested that

affective shopper reactions in terms of arousal or mood, are a result of the influence of store atmospherics that lead to an approach or avoidance behavior from the shopper.

The S-O-R paradigm in retail settings is supported by a number of studies that yield useful predictions about shopper behaviour. Furthermore, it is generally accepted that different cognitive and affective responses are a result of atmospheric cues and stimuli impacting on shopping behaviour (Bitner, 1992; Turley and Milliman, 2000).

Various sensory cues, such as colour, lighting, music, odours which constitute store atmospherics, have a positive effect on shopper reactions (Darden and Babin, 1994; Spangenberg et al., 1996). Moreover, shopper behaviour and perceptions are influenced by in-store components, as well as resulting in positive emotions and feelings.

2.3 Shopper touch behaviour

Touching objects, people or products enables the sense of touch, the largest sensory organ of the body, to incorporate physical contact through the skin into the shopping experience (Klatzky, 2010). In this regard, the hands are identified as our "principal source of input to the touch perceptual system" (Peck and Childers, 2003, p. 35). From research, it is evident that human touch, as a tactile input, is significant in product evaluations of goods as well as services. By touching products, shopper behavior, purchase intentions and attitudes are influenced positively (Peck and Wiggins, 2006).

A general opinion in the literature is that consumers gather information about products by touching them (McCabe and Nowlis, 2003). Studies have also shown that people have different needs for touch and that the effects vary between individuals. It has also been shown that those store environments that allow consumers to physically inspect products by picking them up and touching them are preferred (Krishna and Morrin, 2008; McCabe and Nowlis, 2003). Therefore, allowing shoppers to interact and touch the products should be a competitive advantage for retailers (Grohmann et al., 2007).

Other studies provide evidence that if shoppers are not allowed to touch products in order to evaluate them, they become frustrated and annoyed (Citrin et al., 2003; Peck and Childers, 2003). One of the reasons could be the fact that vision alone is not necessarily enough to judge such products as computers or mobile phones. Important sensory input about hardness, surface, texture or weight is disregarded, so that there may be no purchase decision at all.

Therefore, shoppers generally want to touch products they are interested in and the ability to do so is essential for evaluation. In addition, research reveals that most people use more than one sense at a time in processing sensory information (Elder et al., 2010). For this reason, touch might have significant implications for store atmospherics, especially in the form of point-of-purchase displays. Peck and Wiggins (2006) suggest that displays could encourage touch and enable shoppers to interact with products that otherwise would be ignored, perhaps resulting in impulse and unplanned purchases (Peck and Childers, 2008).

2.4 In-store innovations

Hollander (1960) presented a major theory "The wheel of retailing" as a way to explain retail development and innovations. One aspect was that new types of retailers are established by entrepreneurs, who are innovative in different marketing activities, such as assortment, price and promotion. The theory also attempts to explain the growth of small retailers, as low-margin operators, into large retailers in the form of high-price merchants, such as department stores and supermarkets.

The 'retail revolution' in Britain during the 1980's, characterized by a shift from manufacturing economies of scale to retailing economies of scope, entailed by retailers developing innovative information and supply systems, as well as "new principles of production, a new pluralism of products and a new importance for innovation" (Murray, 1989, p.44). Furthermore, innovations were taking place among retailers with own-label products positioned as retail brands (de Chernatony, 1989). The active role of retailers as innovators was also reflected in developing own-label networks for high-margin and strategically important product areas (Sayer and Walker, 1992).

Recently, innovations have received attention in different aspects of shopper marketing defined as "the planning and execution of all marketing activities that influence a shopper along, and beyond, the entire path-to-purchase, from the point at which the motivation to shop first emerges through to purchase, consumption, repurchase, and recommendation" (Shankar, 2011). Shopper marketing is different to traditional marketing at the strategic and tactical levels. Shankar et al. (2011) suggest that shopper marketing focuses on targeting shoppers in shopping mode, while traditional marketing focuses on consumers and their consumption patterns.

In shopper marketing, innovation is regarded as essential in retail practice, mainly because of changes in shopper behavior. Four major drivers of change are the economy, globalization, regulation and technology that impact on the need for innovations in shopper marketing. Shankar et al. (2011) suggest that shopper behavior impact the need of innovations in shopper marketing, which at the same time, impact shopper behavior why the relationship is bidirectional.

One of the proposed areas for innovation is store atmospherics and design, to which shoppers respond positively and could be related to a more shopper-centric store layout and design. Also, innovations related to customized sensory experiences in traditional stores or on-line channels, are considered as an alternative in understanding how shoppers react to different sensory cues. Also, innovations related to aisle placements and shelf positions could be an alternative in shopper marketing (ibid.).

Moreover, Shankar et al. (2011) suggest that retailers should experiment with such elements as colors, lighting, music, or odors. The authors also express that marketers should conduct controlled field experiments to learn more about shopper behaviour. Following this call from Shankar et al. this is a major argument for the present experimental research.

3 Research question, model and hypotheses

The theoretical and experimental context of this study is intended to answer the following research question: What influence do visual and auditory sensory cues as in-store innovations have on shopper approach and touch behavior at the point-of-purchase in a retail setting?

The basic assumption is that the application of visual and auditory sensory cues as in-store innovations will influence shopper approach as well as touch behaviour at the POP. It is assumed that if the application of visual and/or auditory sensory draw shopper attention to a brand, it will lead to approach behaviour, indicating a desire to examine the brand. If this desire is followed by touch behaviour, it will indicate a deeper interest in examining and evaluating the brand. The use of fingers indicates a positive relationship between attention, approach behaviour and touch behaviour.

The research model illustrates the relationships between visual and auditory sensory cues, shopper approach behaviour and shopper touch behaviour (Figure 1).

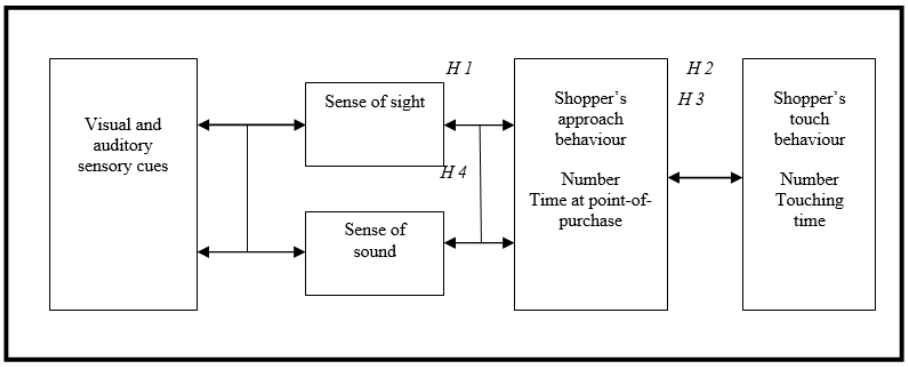

Fig.1 Research model

In order to investigate the positive relationship between visual and auditory sensory cues, shopper approach and touch behaviour, the following hypotheses are tested:

H 1: *Visual sensory cues exert a positive impact on shopper approach behaviour at the point-of-purchase.*

H 2: *Visual sensory cues exert a positive impact on shopper touch behaviour at point-of-purchase.*

Hypothesis 1 assumes a positive relationship between the application of visual sensory cues, shopper attention and approach behaviour at the point-of-purchase. Accordingly, Hypothesis 2 assumes a positive relationship between visual sensory cues and shopper touch behaviour at point-of-purchase.

H 3*: Visual sensory cues exert a positive impact on shopper touching time at point-of-purchase.*

Moreover, Hypothesis 3 assumes a positive relationship between the application of visual sensory cues and shopper's touching time at the point-of-purchase.

H 4: *The combination of visual and auditory sensory cues exerts a positive impact on*

shopper attention and approach behaviour at the point-of-purchase.

Hypothesis 4 assumes a positive relationship between the application of the combined visual and auditory sensory cues and shopper attention and approach behaviour at point-of-purchase.

4 Methodology

The aim of the empirical study was to examine how the application of visual and auditory sensory cues as in-store innovations can influence shopper approach and touch behaviour at the POP in a retail context (Eriksson and Larsson, 2011). It was relevant to study shopper behaviour in relation to hard (durable) products like electronic items with a low degree of product differentiation with regard to vision, sound, smell and touch, compared to products like clothing. For this reason, laptops in the computer department of the German retailer Media Markt was chosen for the study, also given the intense competition between Apple and the PC laptops, which result in lower attention and interest for PC laptops in general in the hypermarket.

4.1 Conclusive research and field experiment

A conclusive research strategy was chosen, since we were interested in confirming the basic assumption of the study that the application of sensory cues should impact shopper's behaviour. Moreover, it was of interest to find out whether we could confirm our hypotheses, in order to advise retail managers on applying sensory cues as in-store innovations at the point-of-purchase. It was also important to conduct an empirical study based on a large sample of respondents, with a quantitative approach measuring cause and affect relationships.

An experimental research design has the aim of generating data presenting the causal relationship between different variables, where these are manipulated. The main purpose of the chosen experimental design was to focus on understanding the relationship between cause and effect and not to prove causality between the chosen dependent and independent variables. The intention was to determine whether the hypotheses that suggest a cause and effect on shopper behaviour could be confirmed through the experiment.

A field experiment was chosen instead of a laboratory one, in order to study shopper behaviour as it really occurs at the POP in a hypermarket. The advantage of having access to natural data was regarded particularly important, in order to bridge the gap between a controlled and real environment. The fact that full control of the experiment would not be possible was accepted, and for that reason we tried to control contextual factors that could affect shopper behaviour during the experiment e.g. low price offerings and music played in the hypermarket.

4.2 Experimental design and observational method

The reason for choosing an experimental design was the possibility to study the impact of sensory cues on shopper behaviour in a real rather than a controlled environment. In a real environment, the shoppers are not controlled and would

experience control as unnatural or strange. Moreover, the shoppers should not know in a real environment that they are being observed during the manipulation, so that their behaviour is natural and transparent, without any influence from the researcher side. It was also obvious that since the manipulation only concerned two possible causal variables, namely visual and auditory sensory cues, and their impact on other controlled variables, the choice of an experimental design was very appropriate.

It was logical to use the observational method, since observations normally take place in real environments where the observed behaviour reflects actual shopper behaviour. Another advantage is the fact that the results of the research are not affected by the respondents' willingness to contribute or participate in the study. Thus, the observational method has the advantage of recording and studying behaviour that is ongoing, without any attempt from the researchers to influence it.

When using the observational method, the role of the researcher is crucial with regard to how the observations are conducted. In this experiment, the role of "complete" observer was chosen, meaning that we did not interact with the respondents we observed. Furthermore, the respondents did not have to take us into account at all and through direct observations, the shopper behaviour was studied as it occurred in real time during the experiment.

In order to document the observations, a category scheme was developed based on eight (8) dependent and independent variables, where four (4) dependent variables measured shopper behavior (variable 1, 2, 3 and 4) and four (4) independent variables (variable 5, 6, 7 and 8) were measured to understand their impact on actual behavior (Table 1). The chosen variables were developed in relation to the research question of whether there is a positive relationship between the application of visual and auditory sensory cues and their impact on shoppers' approach and touch behavior.

Shoppers approach and touch behavior was investigated in terms of how active they were, whether they approach the POP, the time spent at the POP, as well as whether they touch the laptop and the touching time. For the time measurement, two stopwatches were used by the observers, with one in each hand for the time spent in relation to approach and touch behavior. The measurement started when a shopper entered the observation area and stopped when the shopper left the area again.

Table 1. Observation scheme

Dependent variables
1. Active behaviour of shoppers in terms of discussions, pointing at the laptop etc.
– The observed person
– The accompanying person
– Both
2. Approach behaviour of shoppers in terms of getting close to the laptop at the POP
– Yes
– No
3. Touch behaviour of shoppers in terms of physical interaction with the laptop with the fingers
– Yes
– No
4. Shopper behaviour in terms of buying a laptop
– Yes
– No
Independent variables
5. Time spent at POP in seconds
6. Time touching the laptop in seconds
7. Age: _____
8. Gender:_____

The observation scheme was tested before the experiment started and a trial experiment was also conducted. As a result, some minor changes of the observations were made in order to have reliable data from the control group and the two experimental groups.

4.3 Sampling, experiment and procedure

The empirical study is based on an experimental design and was in fact quasi-experimental, with a convenience sample of shoppers assigned to a control group (n = 319), an experimental group 1 (n = 342) and an experimental group 2 (n = 323), in total 984 shoppers. In the sample, female and male participants aged between 20 to70 were represented. The observations took place during five weeks, from Friday to Sunday, at the same time from 12 a.m. to 4 p.m. in the computer department with a focus on one of four shelves of laptop computers.

In order to investigate the influence of visual and auditory sensory cues on shopper approach and touch behaviour the experiment had two experimental groups. Each group was observed for two weeks and before that, the control group was observed.

For experimental group 1, a visual sensory cue was introduced through a large sign with the text “Touch me” that was placed behind the laptop on the shelf, to investigate its influence on shopper approach and touch behaviour. The sign and the message

were chosen as a design element with the colours black and red at the point-of-purchase, in so as to stimulate the sense of sight. The choice of a visual cue was related to the fact that vision is the most important sense for discovering changes in an environment, In order to attract shoppers, the sign was to communicate a personal message, so that the shoppers would approach the laptop and touch it.

For experimental group 2, a combination of visual and auditory sensory cues was investigated through adding a human voice to the large sign beside the laptop. A male voice sequence was played for 10 seconds at the laptop with the following messing: "Hey there, you haven't missed what I have to offer? Do you know that you are allowed to touch me, test me and pick me up to better experience me and what I can do?" The voice sequence was played in an interval at 60 seconds in stimulating the sense of sound. The choice of an auditory cue was related to the fact that sound is a sense that reacts emotionally to music and voices. Since laptops often are considered as quiet products, a human voice could be used to communicate with the shoppers and attract their interest, so that further they examine the laptop by approaching and touching it.

In this experimental context, the introduction of visual and auditory sensory cues as innovations at the POP should encourage shoppers to pay attention to the laptops. It was postulated that this should have a positive impact on shopper approach and touch behaviour.

A manipulation check through a questionnaire was conducted after each of the two experimental groups to find out if the manipulation had been noticed by the shoppers. In total, more than 200 respondents from the two experimental groups were asked. For the first group, five questions were used and the respondents were asked to grade their overall experience of the laptops on a Likert scale. For the second group, the focus was on the human voice and the same questions were asked but the sign was changed to the voice instead. A final question for both groups was also put in the questionnaire, to test whether the respondent had bought a laptop or not (Appendix 1).

4.4 Validity and reliability

The present empirical study demonstrates internal validity, because the chosen independent variables have caused the hypothesized impact on shopper approach and touch behaviour. In experimental research, causality is significant and if there is internal validity, the conclusions from the study can be verified. The suggested hypotheses are accepted and for that reason, internal validity is high.

Concerning external validity, it should be possible to reach the same results for another sample of respondents or in another retail context. The present empirical study is based on a large sample of more than 900 observations and 200 manipulation check questions. This means that the results of the present empirical study are generalizable and that there is high external validity.

When it comes to construct validity, the theoretical framework shows how the present empirical study is supported by previous research. The research model contains the constructs, relationships between independent and dependent variables, and lays the ground for the hypotheses, indicating that construct validity is high.

Finally, the present empirical study demonstrates reliability and should be replicable

without any measurement errors in another research context. The observation scheme and the manipulation check allow other researchers to do the same kind of observations with a large scale. Accordingly, the study has high reliability.

4 Analysis and discussion

Analysis of variance (ANOVAs), Pearson's r as well as descriptive statistics, were used. The main findings are analysed and discussed below, in relation to the hypotheses.

4.1 Hypothesis 1

H_1: *Visual sensory cues exert a positive impact on shopper approach behaviour at the point-of-purchase.*

More shoppers approached the laptop when the red sign with the text in black was introduced. In the experimental group, 44.7 per cent of the shoppers show an increase in approach behaviour, compared with 29.2 per cent in the control group, which corresponds to an overall increase of 53 per cent. Thus, 50 shoppers more approached the laptop during the experiment, compared with the control group.

The difference was statistically significant ($F = 17{,}557$, $p < .000$), therefore confirming the hypothesis (Table 2). The findings indicate that the introduction of visual sensory cues affect shopper approach behaviour and encourage them to approach the laptop at the point-of-purchase.

Table 2. Shopper approach behaviour

	Sum of squares	Df	Mean square	F	Sig.
Between groups	4,008	1	4,008	17,557	,000
Within groups	150,440	659	,228		
Total	154,448	660			

The analysis shows that the application of a visual sensory cue, as in-store innovation, draws attention and influences shoppers in approaching the laptop at the point-of-purchase. Under normal conditions, as for the control group when no sign was present at the POP, the analysis shows that the visual sensory cue caused an impact on shopper approach behaviour.

4.2 Hypothesis 2

H_2: *Visual sensory cues exert a positive impact on shopper touch behaviour at the point-of-purchase.*

More shoppers touched the laptop when the sign with the text was introduced. In the experimental group, 14.6 per cent of the shoppers show an increase in touch behaviour, compared with 8.2 per cent in the control group, which corresponds to an

increase of 78 per cent. This means that 20 shoppers more touched the laptop during the experiment, compared to the control group.

The difference was statistically significant ($F = 6,838$, $p < .009$), thus confirming the hypothesis (Table 3). The findings indicate that the introduction of visual sensory cues affect shopper touch behaviour and encourage them to touch the laptop at the point-of-purchase. According to the manipulation check, 36.2 per cent of the respondents stated that they had been stimulated to touch the computer to a high or even the highest degree.

Table 3. Shopper touch behaviour

	Sum of squares	**Df**	**Mean square**	**F**	**Sig.**
Between groups	,691	1	,691	6,838	,009
Within groups	66,571	659	,101		
Total	67,262	660			

The analysis shows that the application of a visual sensory cue as in-store innovation influences the shoppers in touching the laptop at the point-of-purchase. Under normal conditions, as for the control group when no sign was present at the POP, the analysis shows that the visual sensory cue caused an impact on shopper touch behaviour.

Moreover, a positive correlation between shopper approach and touch behavior at the point-of-purchase was also confirmed through Pearson's r test (Table 4). This confirms the impact of a visual sensory cues regarding the close relationship between approach and touch behaviour. If a visual sensory cue attracts the attention of shoppers, it leads to an approach response, as well as touch behaviour at the point-of-purchase.

Table 4. The relationship between approach and touch behaviour

		Touch	**Buy**
	Pearson correlation	1	-,494(**)
	Sig. (2-tailed)		,000
	N	886	885
	Pearson correlation	-,494(**)	1
	Sig. (2-tailed)	,000	
	N	885	885

The analysis shows that the application of a visual sensory cue as in-store innovation influences shoppers in approaching as well as touching the laptop at the point-of-purchase. It also highlights the intentional, subconscious impact on attention through the eyes, and the relationship between approaching and touching the laptop. This implies that a visual sensory cue impacts not only on shopper approach behaviour, but also their touch behaviour and without the visual cue, no touch behaviour would be evident.

4.3 Hypothesis 3

H3: *Visual sensory cues exert a positive impact on shopper touching time at the point-of-purchase.*

Shoppers touched the laptop for a longer period of time when the sign with the text was introduced. In the experimental group, the mean value of touching the laptop was 2.2 seconds, compared with the mean value of 1 second in the control group.

The difference was statistically significant (F = 3,420, p < .065), thus confirming the hypothesis (Table 5). The findings indicate that the introduction of visual sensory cues positively affects shopper touching time at the point-of-purchase.

Table 5. Shopper touching time

	Sum of squares	Df	Mean square	F	Sig.
Between groups	,074	1	,074	3,420	,065
Within groups	14,329	659	,022		
Total	14,403	660			

The analysis shows that the application of a visual sensory cue as in-store innovation influences shopper touching time of the laptop at the point-of-purchase. It is evident that a sign as an in-store innovation will have such an impact on shopper touch behaviour, inducing them to touch, test and interact with the product. It also allows shoppers to better experience the product and will probably enhance their opinion of the product before a purchase decision.

4.4 Hypothesis 4

H4: *The combination of visual and auditory sensory cues exerts a positive impact on shopper approach behaviour at the point-of-purchase.*

More shoppers approached the laptop when a human voice was introduced together with the sign at the POP. In the experimental group, 48.0 per cent of the shoppers display an increase in approach behaviour, compared with 29.2 per cent in the control group, which corresponds to an increase of 64 per cent. Therefore, 60 shoppers more approached the laptop during the experiment, compared to the control group.

The difference was statistically significant (F = 24,870, p < .000), thus confirming the hypothesis (Table 6). The findings indicate that the combination of visual and auditory sensory cues affect shopper approach behaviour and encourages them to approach the laptop at the point-of-purchase. Moreover, it is evident that the number of shoppers increases with the introduction of the human voice, which means that the effect is greater for the combination of sensory cues than only for visual sensory cues.

Table 6. Shopper approach behaviour

	Sum of squares	Df	Mean square	F	Sig.
Between groups	5,693	1	5,693	24,870	,000
Within groups	146,506	640	,229		
Total	152,199	641			

The analysis shows that a combination of visual sensory cue and an auditory sensory cue as in-store innovation attracts attention and influences the shoppers in capturing attention and in their approaching the laptop at the point-of-purchase. It is clear that the combination of the two sensory cues has a stronger impact, compared to only the visual sensory cue.

According to the manipulation check, some respondents expressed an opinion about the combination of visual and auditory sensory cues in the following way: "*It made me curious. It is good to know that we are allowed to touch the computers" and "I expected something like this from Apple, but not for a PC*".

5 Conclusions

Firstly, in responding to the research question, the findings support the basic assumption that the application of visual and auditory sensory cues, as in-store innovations, will influence shopper attention, resulting in approach as well as touch behaviour.

Secondly, the application of visual and auditory sensory cues impact on shopper approach behaviour at the point-of-purchase in a hypermarket. The analysis reveals that more shoppers approached the laptop after the introduction of a visual sensory cue and this aroused the shopper's desire to investigate the laptop further. The auditory sensory cue through a human voice, in combination with the visual sensory cue, further enhances shopper approach behaviour.

In this regard, the combination of the two had a greater impact on the number of shoppers who approached the laptop. A possible interpretation is that the interplay between the sense of sight and the sense of touch stimulated a multi-sensory brand-experience of the laptop.

Thirdly, in order for the shoppers to investigate the laptop, touch behaviour follows approach behaviour, which illustrates the positive relationship between approaching and touching. The sign with the text Touch me encouraged the shoppers to approach and touch the laptop, resulting in a physical and psychological interaction with the computer. As a consequence, shoppers spent more time at the point-of-of purchase, and touched the laptop for a longer period of time.

Finally, a major conclusion of the presented research is that shopper approach behaviour has a positive correlation with touch behaviour, indicating that if a shopper approaches a product, he or she will probably also touch it. This highlights the significant relationship between approaching and touching, meaning that without approaching, there is no touching.

5.1 Theoretical implications

The research has demonstrated the positive impact on shopper approach and touch behavior at the point-of-purchase of the application of visual and auditory sensory cues as in-store innovations. This confirms the subconscious influence of sensory cues on shoppers and it is evident that sensory cues positively impact on shopper attention, which stimulates approach as well as touch behaviour at the point-of-purchase.

The empirical study also confirms the significance of in-store innovations in shopper marketing, especially related to such considerations as store atmospherics and design, as well as a more shopper-centric store layout (Shankar et al., 2011). The research is a response to the call from Shankar et al. (2011), on the need to conduct controlled field experiments to learn more about retailing innovations. In this sense, the study contributes to the literature on sensory marketing, shopper marketing and retailing in offering new knowledge.

5.2 Managerial implications

The presented research offers guidelines for managers of retail and service outlets regarding the advantages of in-store innovations in enhancing shopper approach and touch behaviour at the point-of-purchase. It is clear that the application of visual and auditory sensory cues encourages and stimulates shoppers to further examine and evaluate products in a retail setting.

In this case, the introduction of a sign, as well as a human voice, had a significant impact on shopper approaching and then touching the laptop. The multi-sensory combination of the sign and the voice was a successful display of PC laptops in the competition with Apple laptops. The cues created an appealing point-of-purchase atmosphere for the shoppers.

In conclusion, the research suggests that the application of visual and auditory sensory cues as in-store innovations, in relation the senses of sight and touch, is a useful strategy in developing an attractive store atmosphere and design.

5.3 Limitations and future research

This field experiment was conducted at the point-of-purchase of laptops in a computer department of a hypermarket, which means that in other retail settings such as stores or supermarkets, the findings could look quite different. Also, the fact that the combination of visual and auditory cues was observed, is another limitation of the study. Accordingly, further research avenues should address other products, other retail settings and other combinations of sensory cues.

Additional avenues for further research could be to examine the role and significance of different sensory cues as in-store innovations. Also, it would be worth investigating how these cues might influence shopper approach and touch behaviour in creating an appealing and attractive store atmosphere and design. To sum up, more field study research is needed, which creates interesting opportunities in developing new knowledge for retail management practice.

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Appendix 1

Q1 *How was your experience of the laptop?*
Very negative (1) Negative (2) Neither (3) Positive (4) Very positive (5)

Q2 *Did you notice the sign/voice?*
Not at all (1) To some extent (2) Neither (3) To a high degree (4) To the highest degree (5)

Q3 *How were you affected?*
Not at all (1) To some extent (2) Neither (3) To a high degree (4) To the highest degree (5)

Q4 *Were you stimulated to touch the computer?*
Not at all (1) To some extent (2) Neither (3) To a high degree (4) To the highest degree (5)

Q5 *Did you notice the sign? (only experimental group 2)*
Not at all (1) To some extent (2) Neither (3) To a high degree (4) To the highest degree (5)

Q6 *Did you buy a laptop?*

Demographics

Age and gender

Looking at innovation through CCT glasses: Consumer culture theory and Google glass innovation

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Abstract. Current innovations can be so radical that common models of innovation diffusion might not be enough for the understanding of innovation adoption. The success of an innovation relies on the functional features of the new product and on how consumers shape the meaning of that innovation. Consumer Culture Theory can help innovation managers by highlighting the cultural determinants of consumer behaviour related to innovation adoption. The work provides a preliminary analysis of how consumers are creating the cultural platform that will determine the success of Google Glass. These glasses are equipped with a computer that connects the user to the Internet and shows layers of information on the display. The findings suggest that consumers are shaping the meaning of this product through two contrasting ideas: that Google Glass will empower users or that it will detach them from reality. The work provides suggestions for innovation managers, including a stronger focus on cultural aspects in innovative thinking.

Keywords. Consumer culture theory, Innovation, Consumer behaviour, Google glass

1 Introduction

Digital technology, biology, robotics, nanotechnology and genomic sequencing: these and other fields are sources of innovation for consumers that go beyond the mere renovation of products or the creation of new products altogether. Today, some innovations are futuristic solutions that take the form of marketable products. For instance, the web-based service 23andMe (www.23andme.com) provides genetic testing to anyone. This service transforms a complex process executed in scientific labs into a marketable service. The possible applications and outcomes of this innovation are numerous, groundbreaking and relate to the cultural paradigms of consumers. Would consumers view marketable genome testing as an empowering tool for medical treatments, as a threat to privacy, or as a technological wonder? Different cultural paradigms can exert their influence on an innovation and define its meanings. This is particularly true when the innovation concept is richer, in terms of meanings and possible applications, than the product or service through which it is conveyed to the market. The innovation of 23andMe concerns human genomes, thus it may cause a debate about the very nature of human being (free will vs. rules, body vs. soul, etc.), which is a key cultural debate.

The work presents two main aims. First, it provides a short review of selected papers on Consumer Culture Theory (CCT) to understand its contributions to innovation. By

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no means does this review pretend to be complete. It is rather an overview of selected literature to stimulate further discussion of innovation and CCT. Second, the work applies culture theory to Google Glass, a radically innovative product with complexities far beyond its technical features and in need of a cultural assessment. The work conducts a preliminary analysis on some key ideas raised by consumers regarding Google Glass.

2 CCT and innovation

The influence of culture on consumer behaviour has been researched extensively. In the past, many scholarly and managerial contributions focused on countries' cultures (e.g. the pivotal work on cross-cultural differences by Hofstede, 1980, 2001). These contributions considered the differences among national cultures essential to defining competitive international marketing strategies (Porter, 1990, 1998; Usunier, 1992). Differences in consumers' cultures were attributed to differences in national or country cultures. Cultures were considered environmental factors. During this time (approximately up to the '90s), studies about the influence of culture on consumer behaviour were part of the discipline of international marketing. Then national cultures experienced a process of fragmentation into a myriad of subcultures (some local, others transcending country boundaries). The concept of culture extended its boundaries outside the strict domain of country or national culture and included any cultural factors affecting consumer behaviour. Consumer behaviour became a more independent discipline with respect to marketing (though the link is still strong; see MacInnis and Folkes, 2010) and consumer culture became a focus of research, adopting sociology, anthropology and ethnography as methodological lenses.

CCT is an essential part of this evolution. Arnould and Thompson (2005) provide a seminal contribution by analysing twenty years of consumer research and defining the key concepts of CCT, a "family of theoretical perspectives that address the dynamic relationships between consumer actions, the marketplace, and cultural meaning" (Arnould and Thompson, 2005, p. 868). Through markets, consumers access some of the symbolic and material resources that define their identity projects. Consumers' cultures shape market-based resources and vice versa. Consumers are interpretive agents, both individually and collectively (Cova et al., 2007). They rework symbols and update, change or confirm the meanings associated with brands, products and market resources.

2.1 Innovation adoption as a cultural interaction between innovator and consumers

A key contribution that a CCT perspective can provide to innovation studies and practice is a deep understanding of the cultural underpinnings of innovation adoption. Innovation literature sometimes does not take into full consideration those cultural factors. This is due to an understandable interest in the product itself and a view of the consumer as a mere adopter of the product, not as a cultural agent. As to the former, a technological view of innovation considers the success of adoption as being largely due to the technical qualities of the product. Very innovative products are irresistible

and the market will react, eventually buying groundbreaking innovation. Innovators look at consumers not as cultural agents but as adopters of innovation in a variety of stages, such as early adopters or late adopters. This simplified view profiles the adopters according to their socio-demographic traits. The consideration of consumers as adopters frames consumers in a narrow way. Consumers do not act as mere adopters, in the sense of purely rational agents deciding the adoption of an innovation. A holistic and more realistic view of consumers as cultural agents would consider the adoption of an innovation as a process that is embedded in a wider cultural background.

Arnould (1989) describes how the cultural setting determines the pattern of diffusion of an innovation. Models of innovation diffusion (Bass, 1969; Gatignon and Robertson, 1985), which are apparently universal, undergo a process of adaptation to local cultures. In an extensive ethnographic and anthropological work, Arnould (1989) illustrates the case of the Hausa-speaking inhabitants of the Zinder Province in the Niger Republic. In this pre-market context, the adoption of innovation was determined by cultural paradigms that differed from those adopted in common market societies. Facing an increase in their discretionary income due to the industrialization of their society, Zinder inhabitants became consumers without replicating *in toto* the Western pattern of consumption. They went from a gift-based economy—in which some goods are exchanged freely or are bought to be exchanged—to a market-based economy, in which the consumer has to exert his or her free choice to purchase products from unknown merchants. Cultural conventions of modesty and the subordinate position of some subjects prevented a quick adoption of novelties. The sense of self that is so strong in Western society was not central among Hausa, who included their network of relatives in the decision-making process regarding a purchase. Surrogate consumers who substituted for the subject in some consumption choices also exhibited this network-based behaviour. Recurring market meetings routinized consumer behaviour acts with the aim of confirming social expectations and ties, rather than simply buying products. Arnould (1989) suggests a revision of the classical propositions of innovation adoption that are universally held and are somewhat culturally sensitive and ethnocentric. For instance, some life-cycle milestones, such as marriage, require the showing of some culturally based "brilliance" from subjects. This compresses the time of adoption of innovation, jumping directly from a pre-cognitive choice to the acquisition of the good. One of the key components of innovation studies is to profile the consumers, searching for pioneers and innovators among them. Personal traits such as income, education and attitude toward risk can be used to describe the innovator. This profiling reassures marketing managers, since the adoption of innovation depends on the presence of a viable segment of innovators. To find those personal traits is to grant the diffusion of innovation. Arnould (1989) deconstructs this proposition by showing that personal traits express themselves in different ways according to the context; thus, they are not associated with a fixed attitude towards innovative products. This study suggests that culture matters for innovation.

The behaviour of Zinder people is not a case limited to a region and a time of the past. This case illuminates the effects that culture exerts on innovation adoption. Each region and each cultural context—even the cultures that are more similar to that of the observer—have their own specificities. Innovators and innovating companies should

see diffusion through emic eyes to see the mind-set and cultural roots of the observed subjects, in addition to their own etic eyes. They should understand those specificities. For instance, observers could consider why mobile applications are diffused in one culture more than in another.

Universal rules to understand and manage innovation adoption do not exist. On the contrary, adoption models should be adapted to local situations. We should not look at innovation just as an effect of a technological novelty or as a new idea by a company that is adopted by consumers. Innovation is an interactive process, where the new product meets the new needs of consumers. These new needs come from a change in the social relationship that breaks the equilibrium of reciprocal social status (Arnould, 1989). When there is a discussion around meanings that were once taken for granted, there is space for innovation. For instance, one of the drivers of widespread diffusion of social media is the new social structure that, in many countries, emphasizes the individual contribution to social debates. In the past, mass media filtered this participation. A new technology and system like social media meets this new need for participation.

A contrast between the cultural background of the company and that of the local market can radically affect innovation. Varman et al. (2012) describe the case of a technological innovation aimed at supporting poor farmers in India. The innovation consists of providing a computer connected to the Internet to selected wheat farmers, who act as coordinators for a cluster of villages. The intention of the promoters of this innovation is that the system would enable better market conditions by leveraging the personal entrepreneurship of local farmers. The initiative is based on the assumption that it is possible to alleviate poverty through private profit-seeking entrepreneurship and limited government intervention. The success of this innovative system is limited because the rich farmers get access to the computerized system, while poor farmers do not get many benefits (Varman et al., 2012). The current power structure affects the outcome of the innovation. Similarly, Miller (2010) studies the introduction of mobile phones into a poor community in Jamaica. The aim of the initiative was to enable small local entrepreneurs to manage their relations with suppliers and customers to enhance their businesses. Instead, local users employed their new mobile phones to keep in contact with family and friends and to manage the complex network of micro-loans on which their economic welfare was based. Instead of stimulating entrepreneurship, the introduction of the mobile phones enhanced the existing structure based on an informal system of micro-credit. These cases show what can happen when a well-designed innovation is employed in a culture that does not necessarily match the cultural context where the innovation was first introduced. The "outgoing" cultural assumptions of the innovator and the receiving cultural context of the consumers do not necessarily overlap.

Markets do not adopt innovations as such. Consumers re-work innovation, as the extensive literature on consumer co-creation shows (Prahalad and Ramaswamy, 2004; Vargo and Lusch, 2004; von Hippel, 2005). This consumer action is not limited to changing the product and adapting it to one's personal needs (even hacking the product). It also includes the negotiation of meanings of new products. Innovation is a process of market-making (Humphreys, 2010) in which consumers play a major role. Giesler (2012) describes the contested meaning of the brand Botox, a cosmetic

remedy to fight wrinkles and the ageing process. During its diffusion, Botox has overcome different waves of controversy drawn from various aspects of the basic cultural opposition of artificial technology against nature (Giesler, 2012). The brand created different stories during its diffusion. Born as hedonic remedy, some portions of the market marked it as a potentially deadly poison. To fight against this perception, the brand repositioned itself as a highly sophisticated medicine. This was contrasted by the idea that Botox would prevent the natural expressions of a face, like smiles. Thus, the company emphasized the fact that with Botox women could truly express their inner emotions. Those who opposed Botox argued that it would create a Frankenstein rather than a human being. Further cycles pinpointed the diffusion of Botox. Consumers opposed the Botox brand positioning based on the cultural opposition between technology and nature. The adoption of an innovation is not a one-time process but an evolving story made of meanings and counter-meanings that accompany the brand in its story.

The contrast between nature and technology is an essential contradiction around which the Botox arguments revolve. The same opposition of nature vs. technology accompanies many innovations. Technological evolution is the source of radical changes in our lives, leading consumers to envisage an era of cyborgs (Campbell et al., 2010; Giesler and Venkatesh, 2010) that seems possible if one considers current innovations like Google Glass. The contradiction between nature and innovation may be a key obstacle for the diffusion of innovation. After ethnographic research of the surfing culture, Canniford and Shankar (2013) show that nature is not just a reality that is given and external to the individuals. The concept of nature is also part of an on-going cultural discourse that shapes it. Consumers try to view the concept of nature through its three essential features: the sublime, the sacred and the primitive (Canniford and Shankar, 2013). However, these features are constantly challenged by contrasting experiences. For instance, a too calm sea with no waves to surf is a betrayal of the idea of a wild and primitive nature. The boring wait for the next wave is far away from the sense of sacred that one should experience when in contact with nature. Individuals overcome these challenges and preserve their sense of nature through cultural strategies (Canniford and Shankar, 2013). The calm sea becomes the confirmation that nature is independent from human control and is pristine. The contemplation of the sea and searching for a good wave becomes a sacred experience. These examples suggest that consumers can accept the contradiction between nature and technology and can save the sense of natural even when contrasting evidence is present. Innovation managers should not try to solve this contradiction, or any other contradiction, that technology may raise. The market can help solve the contradiction and embed the innovative product, even if intensely tech-based, in consumers' daily lives.

Innovation is expressed in tangible products. In addition, the very concept of innovation is part of a cultural system. Kozinets (2008) analyses the ideological dimensions that accompany the idea of technology in the mind of consumers. Consumers assume four distinct ideological positions (or a dynamic combination of them) when facing the notion of technology (Kozinets, 2008): *techtopian* ideology, which considers innovation as inherently good; *green luddite* ideology, which is opposed to *techtopian* ideology and exalts a pristine state of nature that technology would spoil; *techspressive* ideology, which sees technology as a tool for

self-expression and hedonism; and *work machine* ideology, which employs technology as an effective and productive working tool for personal economic improvement and entrepreneurship. These four ideological poles add a further layer to the introduction of an innovation into a market or cultural context. Consumers view innovations through the lenses of their personal technological ideology and through the surrounding cultural context.

2.2 Consumers: Adopters and cultural agents

To summarize, a key contribution from CCT to innovation thinking is that innovators can address consumers on two levels:

1. Rational agent: the consumer adopts an innovative product thanks to its new features, which are superior to those of competitors. Diffusion models work best under this scenario.
2. Cultural agent: The consumer is an individual embedded in a culture and holds a specific ideology regarding technology and innovation. This cultural shell filters and elaborates the technical features of the new product. For instance, the value of a new mobile application for time management depends on cultural concepts, such as time, opposition of working time and leisure time and the degree of familiarity with the smartphone.

The innovating company interacts with the customers through the product's functional features and through the cultural underpinnings of the innovation concept. As to the former, the user rewards innovative features by adopting them and spreading the word to those around them. The consumer can also improve those technical features if the product supports open innovation, which has been the case for many recent innovations. As to the former—cultural interaction—consumers interpolate the cultural foundations of the innovative product, positioning the product on their cultural map.

Functional and cultural interactions between innovators and consumers result in consumer practices, which are the day-to-day expression of innovation adoption. The common measures of an innovation's success are revenues generated from sales, market share, market growth and similar measures of performance. Other parameters, based on a qualitative assessment of the innovation success, are also useful if one adopts a CCT-based framework. Innovators should look at whether the innovation becomes part of consumers' practices and how these practices shape and modify the innovation. Social practices are the execution of a culture through actions, understandings, implicit how-to knowledge and objects (Reckwitz, 2002; Schatzki, 1996). Products are part of those practices (Warde, 2005; see Echeverri and Skålén, 2011 and Schau et al., 2009) for applications of practice theory in consumption). The practice of taking tea, for instance, means arranging actions (having a conversation, following the ritual of serving tea to the guest) and goods (cups, tea, furniture and environment) in a meaningful way. Innovative products reshape practices while, at the same time, practices shape the current use of new products. Practices can also give new functions and uses to old products (Shove and Pantzar, 2005). For instance, the mobile app WhatsApp is an instant messaging system. Its diffusion was very quick. The launch was in 2009 and today it handles an astounding 10 billion messages per day. WhatsApp is a strong competitor for SMS services offered by mobile operators.

WhatsApp has been able to enter the existing social practice of text messaging, both confirming its key characteristics and eliminating some of the limits of traditional SMS services. At the functional level, WhatsApp delivers an enhanced SMS service at zero cost. The deep roots of its success are in its integration in current practices. The SMS address book of a smartphone usually lists relatively few numbers of friends and colleagues, because the social practice of text messaging implies that users will contact people they already know. WhatsApp overcomes this limit by opening the phone book to an unlimited number of people. A WhatsApp user can extend her/his social circle, as well as keep the contacts from the existing circle. WhatsApp enables the user to employ tones, tricks and understanding of the SMS practice in an extended and richer way. WhatsApp has become part of and enriches the SMS messaging practice.

Figure 1 synthesizes the relations between innovator and consumers and the resulting consumer practices emerging from these interactions. Consumers are both rational and cultural agents. As rational agents, consumers evaluate the technical and functional features of the innovation, and then they rationally decide whether they will adopt the innovation. As cultural agents, consumers elaborate the meanings of the innovation, by referring to their own culture, sub-culture, technology ideology and practices. The specific consumer practices regarding the innovation spring from these two rational and cultural processes.

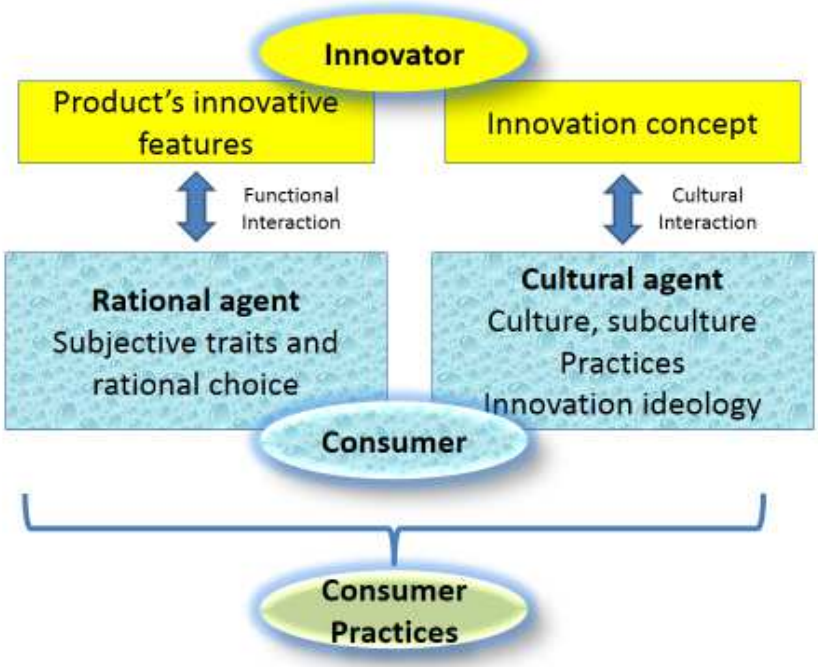

Fig. 1. Innovators view consumers as rational and cultural agents, resulting in consumer practices

3 Methodology

To conduct the empirical analysis on the consumer discourse surrounding Google Glass, social media are particularly useful. Consumers freely and extensively share their feelings and thoughts about products in social media. Thus, social media is an ideal repository of qualitative data to analyse. As earlier research in CCT suggests, the analysis of consumer Web interactions can provide a comprehensive framework to understand some consumer behaviours. Kozinets (2010), for instance, has introduced and developed netnography as a qualitative method that can be employed to get a full understanding of a given issue. For this preliminary analysis of Google Glass, this work focuses on YouTube as a primary source of insights (Pace, 2008). By using "Google Glass" as search keyword in YouTube, one obtains a list of more than 2.2 million videos. This work analysed 50 user-made videos, using the highest ranked in terms of popularity (i.e. number of views) plus other randomly selected videos. The analysis consisted of extracting the key themes of each video and the overarching story that the video conveyed (Pace, 2008). The analysis proceeded until a reasonable level of conceptual saturation about the main conceptual themes regarding Google Glass was reached (Strauss and Corbin, 1998). Documents available online—such as news articles, company press releases, websites and blogs—complemented the analysis.

With reference to Figure 1 above, the analysis of Google Glass explores the consumer as cultural agent and examines the meanings that consumers create around the innovation concept behind Google Glass. The key research question leading the analysis is determining which cultural poles consumers adopt to shape the meaning of Google Glass.

4 The case of Google glass

In this section, the work conducts a preliminary exploration of a radical innovation whose aim is to change consumer behaviours: Google Glass. By adopting a CCT framework, one can get an understanding of the possible evolution of this new technology. Google Glass is at its initial stage of diffusion and the product is not a widespread innovation yet. Consumers can help define the future applications of Google Glass even though the product is not widely available yet. Consumers are already engaged in imagining possible uses of Google Glass. Consumers share their thoughts and shape a cultural platform that lays the groundwork for the introduction of Google Glass, determining the degree of its future success.

Google Glass is an augmented reality glass. Google Glass enhances the function of eyeglasses by integrating them with a wearable and connected microcomputer. The display shows information to the users, who can interact with Google Glass with their voice. Google aims to introduce augmented reality in our daily life. The potential applications are abundant. For instance, one can look at a product in a supermarket and Google Glass would show data around the package; a tourist can visit a city while following an interactive guide displayed in front of her; a runner can monitor in real time the meteorological conditions and other data related to his run; and an architect

can look at alternative renderings for a project.

Google Glass is an innovation that will likely spark further innovation as applications emerge. Google Glass could be the new platform to integrate or even replace current devices such as smartphones and tablets. As with many radical innovations, Google Glass is waiting for problems to solve through its creative applications. Similar to other platforms—like the iPhone, for instance—Google considers Google Glass as an ecosystem that entrepreneurs and developers can contribute to with their own ideas. Google is thus inviting external entrepreneurs and innovators around the world to imagine applications and services to deliver through Google Glass. As Bill Maris (managing partner of Google Ventures) states, "the truth is, no one can honestly predict where this new technology will take us. Not yet. And that's exactly what's exciting. We do know that smart entrepreneurs and engineers are going to develop amazing experiences through Glass. Glass will evolve quickly…" (2013). Venture capitalist John Doerr adds that the "best ideas for the Glass platform will come from entrepreneurs—they always do" (2013). Marc Andreessen, another partner on the project, confirms that "as with the Internet and smartphones, a huge amount of work will be done by third-party developers to fully realize the Glass vision. Glass brings developers a new springboard for creativity and an amazing new platform to build the defining services of the future" (2013).

These statements, released by the company and its partners, confirm that Google pursues a strategy primarily based on external developers. Thus, developer and entrepreneurs are key actors in the evolution of Google Glass. Consumers, on the other end of the spectrum, can also play a major role. It is interesting that consumers can affect Google Glass even though the product is not fully commercialized yet. Consumers shape the cultural landscape where Google Glass will be integrated. Thus, consumers are the gatekeepers of the success of this innovation. What can consumers imagine doing, thanks to Google Glass?

The user-generated videos posted on YouTube are varied. Some of them are parodies of the product, as often occurs on social media platforms, where funny videos achieve popularity and are a popular and recurring genre.

Table 1 provides a synthesis of some of the analysed videos. It lists and classifies the most popular user-made videos regarding Google Glass.

Table 1. Google Glass videos: the most popular user-generated videos.

Title	Author	Views (million; approximate)	Genre	Plot and morale
GOOGLE GLASS S**S!	Smosh	3.9	Parody	Google Glass obstructs, rather than empowers, common daily activities (walking, waking up, ordering food). Google Glass is depicted as intrusive and detached from real occurrences.
How Guys Will Use Google Glass	DartanionLondon·	2.9	Parody	A romantic date goes astray due to the incorrect use of Google Glass. The video shows the impossibility

				of matching the hard data and soft skills needed in human relationships.
Google Glasses: A New Way to Hurt Yourself (parody of Google's Project Glass)	Tom Scott	2.6	Parody	The user keeps bumping into light poles and other obstacles while walking, because Google Glass displays distracting data that obstructs the view.
Windows Project Glass: One day too...	vlakkeland	2.4	Parody	Google Glass keeps popping up windows that ask check questions (e.g. confirming actions, running anti-virus), in the same way laptops do. The pop-ups do not help the user in his daily routines. The video ends with the user falling down because an error message obstructs the screen.
Battlefield 5 on Google Glasses (the Marine revenge)	ThereIsaCanal	1.9	Commercial (promotion of a videogame	The video promotes a multi-player war videogame by showing how it could be paired in a real environment using Google Glass. Google Glass can provide game players an immersive experience. It can substitute virtual environments with real environments augmented by Google Glass, where the player can move and play.
I used Google Glass	TheVerge	1.7	Product expert review	Interviews with engineers and developers of the product. A key issue raised in the interviews is how to make technology unobtrusive and put the technology “out of the way” but still present when it is needed. Ideally, the user would live her/his normal life empowered by Google Glass. Another issue raised is the contrast between being human and wearing a robot-like object.
GOOGLE GLASS and ALL THAT A$$	sxephil	1.2	Product review	The product review is a short part of a self-made news show. Google Glass is described as helpful for producing and keeping memories. It may be a little weird as someone may look like a cyborg.
Google Glasses (how it works)	taoistflyer	1.1	Product review	The tone of the video is sober. A professional voiceover illustrates the technical features of Google Glass while a 3D rendition of

				Google Glass is shown. The possible applications of Google Glass are many and the future will make them real.
ADmented Reality - Google Glasses Remixed with Google Ads	rebelliouspixels	0.9	Critical remake of the official commercial	The user reworks the official trailer by Google, adding possible ads that would characterize the experience with Google Glass. For instance, in a scene the main character plays a guitar and ads for guitars shops pop up in his view. The video expresses the idea that, in addition to useful data being shown, Google Glass would also show commercial data
St. Patrick's Day [through Google Glass]	stuntbear	0.9	Parody	The video is a parody of a young person who is arrested for drunkenness. Google Glass acts as a sort of mute witness, showing to the watcher the events that bring the main character to jail. The video depicts a scenario where the options that Google Glass offers would be employed for funny and silly purposes, without really improving the daily life of the user
Project Glass - Trampoline Video	Jason O. Gilbert	0.8	Reality video	It is a 15-second video where a user wears Google Glass while doing backflips on a trampoline. No music or voices are present. The video simply shows the perspective of a person doing movements on a trampoline.

A main theme that can be drawn from the user-generated YouTube videos analysed is the offline/online (dis)integration. Google Glass raises the issue of whether the digital life and the offline life are integrated or opposed. This is a lively debate comparing augmented reality to digital dualism (Jurgenson, 2011). The augmented reality discourse would advocate the idea that "the digital and the physical, media and humans, have imploded and augmented each other. We cannot focus on one side, be it human or technology, without deeply acknowledging the other" (Jurgenson, 2012, p. 84; see also www.cyborgology.com). The augmented reality discourse applied to Google Glass exalts the empowered human being. Google Glass enhances one's life through various functions, demonstrated in one of its official trailer videos, "How It Feels [through Glass]" (Google, 2013):

- *Memory of experiences.* The installed video camera is always ready to record any moment of the day. Google Glass is a silent witness of 1) exceptional moments, like hang gliding in the sky or parachuting; 2) memorable moments, like a dance recital; and 3) normal family memories, like a birthday.
- *Interaction*. Video-calls are richer and more experiential. The listener can

watch the same scene experienced by the Google Glass user. They can share the same experience as it unfolds in front of the subject.

- *Information*. Driving a car in an unknown city is easier thanks to the navigation system; catching a plane is stress-free thanks to real time information; and visiting a shop is more informative. Google Glass provides interactive information for any circumstance.

These functions can be combined together, as in the example of diving in an ocean among beautiful fishes (a memorable experience) and asking for information about the species (information).

Google Glass promises a smooth experience of augmented reality, achieving a state of a cyborg living a normal—though empowered—life. Figure 2 shows some of these augmented experiences, either ordinary or extraordinary.

Fig. 2. Empowering (extra)ordinary moments with Google Glass (Screenshots from the Google Glass trailer "How It Feels [through Glass]").

Contrasting the idea of an augmented reality, the digital dualism discourse sees the limits of Google Glass. According to digital dualism, the "real" world is offline, while the online realm is a shadow of that reality. The digital world brings some risks to our life. The digital dualism discourse would frame Google Glass as a synthesis of those risks, as the following themes suggest:

- *Invasive technology*. Falling down, hitting a pole and other incidents are part of the parodies related to the product. According to this perspective, Google Glass can obfuscate the user's view, rather than empowering it. In addition to the humorous effect, this recurring theme encourages the idea that digital

technology can be an intrusive presence in real life and hampers common daily activities like walking around. The natural function of human eyes is not empowered by this innovation. The interactive display of Google Glass becomes the symbol of the separation between digital and real life. Instead of being a transparent screen with useful information, it is framed as an opaque wall filled with useless data.

- *Disjunction between human and machine*. The digital dualism view emphasizes that humans and machines cannot be combined yet. The screen is described as being filled with a deluge of unmanageable information. The interaction between humans and machines is not smooth. The computer regularly misunderstands the human who is trying to manage the system with simple instructions. The image of a real body disconnected from its electronic glass contrasts with that of a well-functioning cyborg where electronic and organic parts would be perfectly integrated.
- *Out of fashion*. The product is sometimes presented as uncool or too "nerdy" to compete with common eyeglasses. The design reminds consumers of technical equipment instead of a fashion accessory.

The three themes indicated above would frame Google Glass as an innovation that does not integrate itself into the normal cognitive and bodily functions of a human being. In addition, this innovation would break the intangible rules of fashion. These themes are rooted in the idea that digital and "real" are still far away from each other. This idea is at the core of the digital dualism discourse.

Other meanings surround Google Glass. The opposition between digital dualism and augmented reality does not represent all of the cultural underpinnings of this innovation. However, this opposition may contain a relevant part of the debate around the product and may shape the evolution of the Google Glass innovation.

5 Conclusions

Most of the literature on innovation focuses on how consumers collaborate on radical or incremental innovation. This work emphasizes instead the role of consumer culture for innovations (like Google Glass) that are so groundbreaking that they can be considered futuristic. For these innovations, the cultural mechanism through which consumers mould the innovation meanings is particularly relevant. Consumers' culture provides a shared cultural thread that may define which of the many potential applications of the innovation will likely emerge. The many applications of Google Glass lead to various questions, including the following: Can Google Glass be used for professional purposes or it is a product for entertainment, and is it a form of empowering users or an example of corporate control over users? A cultural analysis can help answer these types of questions by examining how individuals imagine and create the cultural platform that will host Google Glass. One can apply the same approach to other groundbreaking innovations.

Google Glass illustrates how consumers, outside the company, create part of the meanings surrounding innovation. As suggested by CCT, consumers create the meanings of the innovative product by using cultural poles such as augmented reality

and digital dualism (Jurgenson, 2011, 2012) that are part of a wider and lively debate. Consumers adopt a general attitude towards technology (Kozinets, 2008) and from that perspective they work through the possible meanings of the innovation. Through this cultural mechanism, consumers accommodate or reject the innovation into their cultural landscape.

The company is part of this process. The company has a variety of tools to accompany its innovation in the cultural landscape. The company can

- *Launch the idea before the prototype is ready*: The evolution of an innovation is a story of an idea that gradually takes the form of an object. Google understands this process. To make the story unfold, the company launched the idea of Google Glass before its full commercialization. Early in the innovation process, individuals can start creating stories and imagining future uses of the product.
- *Let consumers participate as cultural agents*: In collaborative projects, consumers contribute and define technical aspects and features of the product. Most of the extant literature focused on this consumer role. Consumers can also work at a more abstract level, by detailing and negotiating the meanings of an innovation. The resulting outcome is the position of the product within the appropriate cultural background.
- *Adapt the meaning of the innovative product*: Well-designed communication campaigns and marketing strategies can place the innovative product in a more appropriate cultural background and then let users develop further meanings from that starting point. Google positions Google Glass in the cultural realm of products that revolutionize lifestyles and mark a leap forward from the past. The company has ample room to enrich these meanings by co-creating them with consumers.
- *Observe on-going consumer conversations around the product*: The creation of meanings by consumers does not stop at the product's launch. Consumers continue their conversations around the product in a variety of forms, from debates in specialized forums to videos posted in YouTube. The trajectory of the product life cycle can be adjusted according to this discourse. For instance, in the future, the conversation around Google Glass might hypothetically turn towards the literacy of consumers and the skills required to use the product. By observing the emergence of tutorials on how to use the product, Google might enter this conversation with its own tutorials. This move can be made only through a continuous monitoring and cultural analysis of consumers.

The present study can be further improved and its limitations can be overcome in three areas: 1) extend the study of Google Glass with an on-going longitudinal study, wherein future researchers may observe how Google Glass will spread and which consumer practices will gain a foothold; 2) to fully understand the consequences of new technologies entering the market, future researches can explore other groundbreaking consumer technologies that, like Google Glass, extend the abilities of consumers; and 3) conduct interviews with users on their inner experiences and with managers to understand their implicit expectations and strategies.

The emerging figure of the innovation manager today must be richer than in the past. The innovation manager should be a professional with a wide range of competencies.

The innovation manager should possess technological and managerial skills and some anthropological knowledge and sensitivity towards cultural issues. As the case of Google Glass suggests, offering an innovation to the market necessitates a clear understanding of the cultural underpinnings through which consumers will accept or reject the innovation. In order to create this "enhanced" curriculum the following steps could be taken: 1) business schools, in their courses on innovation, could provide educational resources and lectures based on anthropology and the CCT literature; and 2) innovation managers could organize forums and occasions to exchange ideas regarding general trends in consumer cultures, regardless of specific industries and sectors; this exchange of ideas would benefit innovation thinking in general.

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Creating a sustainable innovation environment within large enterprises: a case study on a professional services firm

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Abstract. This paper considers the question of which structures, strategies and practical activities large firms can use to successfully create a sustainable innovation environment within an organisation. The paper has a special focus on communication activities used to support this change process. Using the ADKAR change management model as the underlying framework, this study analyses the story of a large professional service firm's national innovation program to show and discuss a successful example. The paper shows how the firm successfully managed both the change project and the stakeholder change to transform the nature of their organisation. The paper provides valuable insights for professionals, practitioners, consultants and academics involved in or studying the creation of innovation and how to affect this within large organisations.

Keywords. innovation program; innovation management; sustainable innovation environment; large enterprises; ADKAR change management model; communication; organisational change; stakeholder change; structures, strategies and practical activities

1 Introduction

The growing interest in innovation within large organisations has developed alongside major changes in the academic, technical, political and business environment. Especially intensification and rapid changes in the competitive environment (Siguaw et al., 2003), fostered by factors such as globalisation (Gummesson, 2002) and faster technological development (Santoro and Chakrabarti, 2002), increased the need for an immediate adoption of these changes and the development of innovative products, services, processes and business models (Szerb, 2003).

Whilst innovation, which can be understood as the successful introduction of new products, services, processes or business models (Luecke and Katz, 2003), has been shown to be a key driver in organisational growth (Tucker, 2002; IBM, 2006), innovation is still not completely understood or accepted by those involved in large firms. The responsibility to shareholders, need to manage risk, lack of understanding of innovation (including its benefits and appropriate processes to facilitate it within the organisation), and desire not to be distracted from current business are some of the reasons for this.

With there still being no commonly accepted method for establishing a successful

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firm-wide innovation program that can be used in different sectors and with the development of innovation strategy theory still in a growth phase (Davey et al., 2008), still far from reaching maturity, the ability to get resources committed at the executive level can be difficult. Whilst the Google approach of allowing staff to have 20% of their time dedicated to new venture creation (Carr, 2007) has been successful in achieving growth within the software industry, it may not be realistic for most large firms.

Establishing a common definition for innovation and vision of how it can assist the firm's objectives is a vital first step in establishing an innovation program. This process however can be extremely problematic within large firms owing to the complex nature of large organisations as well as the often difficult task of getting buy-in from key personal at the top level of the organisation. Conversely, getting understanding, trust and acceptance of the benefits and process of innovation by employees, suppliers, customers and shareholders can also create significant issues in getting momentum for an innovation program.

Therefore, the objective of this paper is to create a better understanding of which structures, strategies and practical activities large organisations can use to successfully create an innovation environment within an organisation with special focus given to communication activities used to support this change process. In order to do so, this paper uses the case study of a large professional service firm and its innovation program – a program recognised as a successful example in how to engender a more innovative corporate culture.

A further objective of this largely exploratory study is to develop a framework for the infusion of innovation into a large organisation rather than how to build an innovative organisation. This paper therefore is targeted at professionals, practitioners, consultants and academics involved in or studying the creation of innovation and how to affect this within large organisations.

This paper is organised as follows. Firstly, the next section briefly reviews the literature with respect to the creation of an innovation environment as well as to organisational change. Following an outline of the ADKAR model (Hiatt, 2006) acting as the theoretical framework, section four presents the research design of the present study. Chapter five then introduces the firm's innovation program as well as describes the methods they employed in building momentum for the innovation program within and outside the firm with special focus on communication methods used. The paper outlines the full context of the program so that the reader can understand the way in which the firm combined strong internal and external communication with hands-on innovation activities in order to win over stakeholders in the organisation. Following a discussion of the results, the paper closes with a conclusion and suggestions for future research.

2 Literature review

Research on creating a sustainable innovation environment within enterprises is closely linked with the concept of entrepreneurship and especially with the concept of intrapreneurship. Following Schumpeter (1934) as well as Drucker (1985),

entrepreneurship can be defined as "the process of uncovering and developing an opportunity to create value through innovation" (Antoncic and Hisrich, 2001) which is also the core of organisational innovation. More recently, research on intrapreneurship (Pinchot, 1985), which is also called corporate entrepreneurship (Zahra, 1991) or corporate venturing (Stopford and Baden-Fuller, 1994), has evolved. This research stream focuses on the application of the entrepreneurship concept within existing organisations (due to the common usage of the term entrepreneurship this study stays with the term but refers hereafter to its application within existing organisations). Today, broad consensus is reached that fostering entrepreneurship can help to enhance a company's growth and profitability (Zahra, 1991). Acknowledging this potential, the question arises whether or not an organisation can foster entrepreneurship, if so, how? Since entrepreneurship takes place in interaction with its environment (van de Ven, 1993), organisations need to provide an innovation supporting environment in order to enhance motivation, inspiration and drive (Russel, 1999). Most researchers believe, that environmental factors such as organisational cultures, social networks, reward systems and adequate resource allocation can foster entrepreneurial spirit and help to extract entrepreneurial value (e.g. Hisrich and Peters, 1998; Gnyawali and Fogel, 1994). Moreover, clear goals, strategies and tasks are needed to encourage employees to act as entrepreneurs. Given the required time, space and monetary as well as non-monetary resources, entrepreneurs are able to exploit their full potential and to develop new ideas resulting in organisational growth and competitive advantage.

Today no accepted method for creating a successful and sustainable innovation environment exists. Rather, vague concepts such as the concept of 'organizational slack' which allows staff to have a certain amount of time (15 to 20 percent in the cases of Google and 3M) dedicated to new venture creation are known (Carr, 2007; Bartlett and Mohammed, 1995). However, to exploit the mentioned potential, organisations need a strategic approach to change themselves to create an environment suitable for entrepreneurship.

The following section briefly reviews the literature on firm-level innovation models as well as change management – the two parent theories of this research.

2.1 Firm-level innovation models

The use of innovation models to explain and/or guide innovation management has a long history. In his seminal work, Rothwell (1991) characterised 5 generations of innovations models, from the 1950s until today.

First generation innovation models (1950s to mid-60s) are simple linear sequential process models focused on technology push. Here, the emphasis is on the research and development (R&D) process with the market/customers just being the 'receiver' of the innovation, thus not being the initiator of the innovation and/or shaping the innovation in the commercialisation process. *Second generation* innovation models (mid-60s to 1970s) are still simple linear sequential however with the market being the starting point of innovation. Also called market pull, customers / consumers represent the source of innovation. In these models, R&D reacts based on the market needs identified. Compared to first generation innovation models, these models focus

more on marketing. *Third generation* innovation models (1970s to 1980s) combine the key aspects of the first and second generation models, namely technology push and market pull. With the first two generations being sequential models, marketing and R&D are integrated in the third generation with feedback loops existing between the different stages of the model. *Fourth generation* innovation models (1980s to 1990s) are focused integration of parallel teams / departments / activities (e.g. marketing, R&D, product development, product engineering, manufacturing). The models consider not only the integration within firms, but also the external integration with external organisations and individuals such as suppliers and customers. *Fifth generation* innovation models (1990s till today), also called systems integration and networking models, are fully integrated parallel development models. The main differences to fourth generation innovation models are the extensive usage of information technology (automating and speeding up many processes) as well as wide integration of network partners, both horizontally as well as vertically integrated.

As the above described development illustrates, innovation models have become more and more complex, inter-disciplinary and integrated over time. Innovation models and firm-level innovation management are not considered anymore as a simple linear process containing a small number of activities only, but integrates various aspects from a wide range of disciplines. These aspects, often also mentioned in literature as key success factors, include creativity (e.g. Amabile, 1988) and entrepreneurship (e.g. Drucker, 1985; Burgelman and Sayles, 1986), cross-functional teams (e.g. Baldridge and Burnham, 1975;) and product / project champions (e.g. Rothwell et al., 1974), team structure (e.g. Schon, 1963; Frohman, 1978) stage gate processes (e.g. Cooper, 1983), leadership (e.g. Clark and Fujimoto, 1991), customer and user integration (e.g. von Hippel, 1976, 1986; Rothwell, 1972), innovation culture (e.g. Burns and Stalker, 1961), integration of external sources and organisations (e.g. Chesbrough, 2003), absorptive capacity (e.g. Cohen and Levinthal, 1990) and internal and external communication (e.g. Marquis, 1969; Rothwell, 1972; Rothwell et al., 1974).

Due to the multi-facetted nature of firm-level innovation, introducing a new, or restructuring an existing, innovation program within organisations can be considered as a highly complex and time-consuming activity. As innovation programs have an influence on the work of many employees in an organisation, change management is often applied to increase the chances of success when new innovation programs are introduced or an existing innovation program is advanced. Therefore, the next section will briefly review existing literature on change management.

2.2 Change management

Due to the increasing need of (corporate) renewal in today's knowledge society, fostered by factors such as faster technological development or globalisation, change management has attracted a lot of interest in the past decades. Various starting points for discussions on change management can be identified in literature, e.g. discussions on incremental vs. radical change (e.g. Burnes, 2004), planned change vs. continuous change (e.g. Burnes, 2004; Peters and Waterman, 1982) or the discussions on ambidextrous change (e.g. Duncan, 1976). For a more extensive review on change management literature please refer to Iles and Sutherland (2001). In this section,

however, the focus will be on different definitions and perspectives of change management.

Change management definitions primary focus on three different perspectives: (i) change management as a systematic process, (ii) change management as a means of transitioning people, and (iii) change management as a way to achieve an outcome / make an impact. While some definitions focus on just one or two perspectives others integrate all three. Ryerson (2011, pp. 4-5) presents some example of definitions, primary from practice. Key elements of these definitions include:

- to approach systematically and apply knowledge (process perspective),
- to lead, manage and enable people (people perspective),
- to help people transition (people perspective),
- to accept new processes, technologies, systems, structures, and values (outcome/impact perspective),
- to transition employees from their present way of working to the desired way of working (outcome/process perspective).

A definition that integrates the three perspectives has been developed by the Change Management Learning Center (cited through National Learning Consortium, 2013, p. 1):

> *Change management refers to "the application of the set of tools, processes, skills and principles for managing the people side of change to achieve the required outcomes of a change project or initiative."*

This definition integrates the systematic process and the resources used in the process (tools, skills, principles) and the "people side" of the change, and states that a certain outcome/impact is expected.

Indeed, transforming an organisation towards an innovation-friendly environment, and convincing the different internal and external stakeholders of innovation is often a very hard task due to the necessary (often large) extent of change in an individual's thinking and acting. There is a growing view that resistance to change is a natural phenomenon (Buchanan and Huczynski, 1985) and that initiating change often results in a process which is accompanied by competition and hostility (Lindblom, 1994). As a result, organisations need to find appropriate organizational structures, strategies and activities to force a change of their different stakeholders which, in turn, results in greater innovation activity, new income streams as well as organisational growth. Figure 1 shows a conceptual framework covering these three elements and the perspectives derived from the definitions presented above (process, people, impact).

Fig. 1. Conceptual framework

In the next section different change management models are discussed to identify the most suitable one for this research purpose – namely understanding the creation of a sustainable innovation environment within large enterprises.

3 Theoretical framework

Literature refers to a variety of models which can be used for explaining and fostering organisational change. For instance, the McKinsey 7S Model developed by Peters and Waterman (1982, 1990) breaks down an organisation into seven elements which make up an organisation, namely shared values, strategy, structure, systems, style, staff, and skills. Since these elements are linked to each other, the model can be used to diagnose organisational issues and to plan organisational change processes. Another change management model developed by Lewin (1951) focuses on the process of change. Lewin's model refers to a three-stage change process of unfreeze, change, and re-freeze. Basically, this means that inertia/resistance has to be overcome first (unfreeze) before change can occur (change) and the new situation can be stabilised (refreeze). Yet another model can be found in Kotter's (1996) book 'Leading Change'. Kotter proposes an eight-step process for creating organisational change, including (1) establishing a sense of urgency, followed by (2) creating a guiding coalition, (3) developing a vision and strategy, (4) communicating the change vision, (5) empowering broad-based action, (6) generating short term wins, (7) consolidating gains and producing more change, and finally (8) anchoring new approaches in the culture.

While all three models provide valuable insights into change and its management, none was seen as optimal to investigate the change of an organisation and its stakeholders towards an innovative culture. McKinsey's 7s Model focuses on building blocks, but neither on the change process itself, nor on the individual's change required. Lewin's unfreeze-change-refreeze model, on the other hand, provides a too simplified look at the innovation change process not being able to handle its complex nature. Lastly, Kotter's eight-step model provides a detailed reflection of the change process, but does not put the focus on the individual which is recognized as being a key component in change management in respect to innovation.

Since people rather than processes are seen as the main priority of any successful and sustainable change management approach (Tierney, 1998; McAlpine and Jackson, 2000; Dawson and Jones, 2003), the ADKAR model (Hiatt, 2006) has been highly valued for its separate consideration of the change process for employees and has been chosen as the theoretical framework of present study. Consisting of five building blocks (awareness, desire, knowledge, ability, and reinforcement), the ADKAR model looks at individual change management, meaning how change can be fostered at a personal level (x-axis in figure 2). However, the model also considers the phases of a change project, namely business need, concept and design, implementation, and post-implementation (y-axis) since successful change can only happen when both goals are achieved (project level as well as employee level goals).

In contrast to the original ADKAR model, the model used in this study has been altered slightly. Rather than simply looking at the change made by employees, this study considers all stakeholders involved in the change process (e.g. employees, suppliers, customers or investors). Figure 2 shows the slightly modified model graphically.

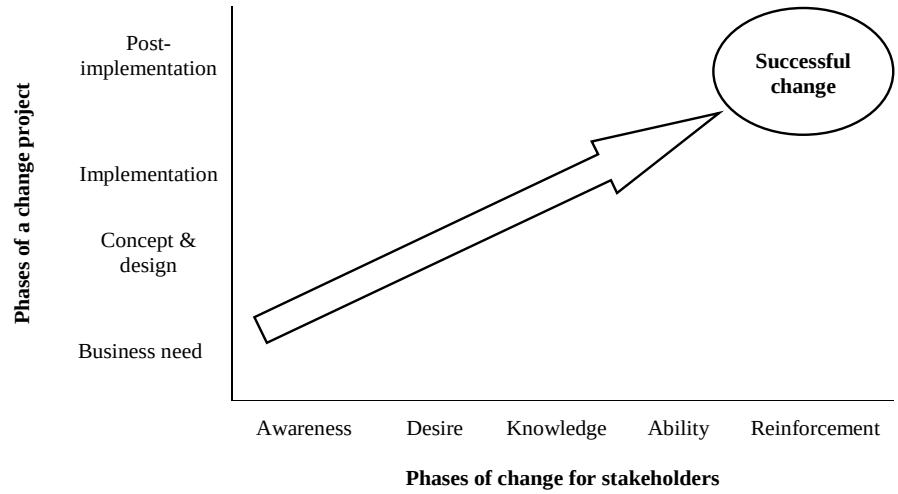

Fig. 2. The ADKAR model (following Hiatt, 2006, p.59)

According to Hiatt (2006) the five elements of the model (awareness, desire, knowledge, ability, and reinforcement) must occur in sequence and are cumulative. This means that all building blocks need to be present to execute a successful and sustainable change. Furthermore, organisations need to establish the five elements in order meaning that they have to start with raising awareness before awakening desire, creating knowledge, forcing abilities, and lastly fostering reinforcement. In the case that one of the first elements is weak, the whole change begins to break down. For instance, change will fail if stakeholders are aware of the importance of innovation and have a desire to take part in creating new innovations but lack the required knowledge and ability to innovate. Therefore, organisations need to look at each element in sequence and foster their achievement. The following table 1 shows some factors influencing the success of each element.

Table 1. Factors influencing each element of the ADKAR model (Hiatt, 2006, p.45)

ADKAR element	**Factors influencing success**
Awareness of the need for change	• A person's view of the current state • How a person perceives problems • Credibility of the sender of awareness messages • Circulation of misinformation or rumours • Contestability of the reasons for change
Desire to support and participate in the change	• The nature of the change (what the change is and how it will impact each person • The organizational or environmental context for the change (his or her perception of the organisation or environment that is subject to change) • Each individual's personal situation • What motivates a person (those intrinsic motivators that are

	unique to an individual)
Knowledge of how to change	• The current knowledge base of an individual • The capability of this person to gain additional knowledge • Resources available for education and training • Access to or existence of the required knowledge
Ability to implement required skills and behaviours	• Psychological blocks • Physical abilities • Intellectual capability • The time available to develop the needed skills • The availability of resources to support the development of new abilities
Reinforcement to sustain the change	• The degree to which the reinforcement is meaningful and specific to the person impacted by the change • The association of the reinforcement with actual demonstrated progress or accomplishment • The absence of negative consequences • An accountability system that created an ongoing mechanism to reinforce the change

Amongst other applications of the ADKAR model, Hiatt states that it is a "learning tool for teaching change management, especially when analyzing case studies of successful and failed changes" (Hiatt, 2006, p.60). Agreeing with Hiatt's statement, the ADKAR model was chosen to act as the theoretical framework of present study.

4 Research design

According to the problem of successfully carrying out a change in the behaviour of an organisation's stakeholders with respect to innovation, the aim of this paper is to contribute to the research stream of creating sustainable innovation environments within large enterprises. In this context, a large enterprise can be defined as having 250 or more work units and having either 50 million Euro or more annual turnover or 43 million Euro or more annual balance sheet total (European Commission, 2003). A more precise research question is as follows:

> *Which structures, strategies and practical activities can be used by large organisations in their quest for infusing a more innovative culture by instituting a firm-wide innovation program?*

In order to answer the research question presented, a descriptive, qualitative research method was applied. In contrast to exploratory and causal research which explore circumstances and coherencies (Kotler et al., 2006), descriptive research aims to picture "specific details of a situation, social setting or relationship" (Neuman, 2000, p.21). Due to the fact that setting up an innovation program within large enterprises and convincing different stakeholders is still a not well researched field, a qualitative approach was chosen. Strauss and Corbin (1998) as well as Denzin and Lincoln (1994) state that qualitative research is an appropriate method for understanding

phenomena which are rather unknown so far, and for exploring new perspectives/concepts. According to Yin (1984) who suggests to choose the research strategy by evaluating three criteria (type of research questions, the researcher's control over behavioral events, and focus on contemporary events), case studies were identified as the most suitable method for this research project. Case studies aim to investigate contemporary phenomena within their natural settings (Benbasat et al., 1987) and are appropriate to research 'how' and 'why' questions (Yin, 1984). Generally, case studies can be undertaken in order to provide description, test theory or generate theory (Eisenhardt, 1989, Kidder, 1982; Pinfield, 1986; Gersick, 1988). The interest of present study is neither to generate nor test theory. Rather, it aims to provide description how a company achieved the goal of convincing their stakeholders of innovation. As a result, the study has an illustrative character.

When undertaking case study research it is crucial to select a case which contributes to answer the research question. Therefore, theoretical sampling was applied instead of statistical sampling. Theoretical sampling refers to a selection which is based on a case's richness of information (information-oriented sampling) and does not take into account how representative a case is (statistical sampling) (Glaser and Strauss, 1967; Strauss and Corbin, 1990). In regard to choosing the right case, different strategies can be applied. Flyvbjerg (2004) outlines that researchers can use extreme/deviant cases to study unusual situations (problematic or especially good cases), maximum variation cases to determine the significance of circumstances, critical cases to allow logical deductions with maximal ramifications for other cases, or paradigmatic cases to establish a school for a certain domain.

Since this study's purpose is to look at a successful case, the extreme/deviant strategy was applied and *the Firm* has been identified as an appropriate example and provides a remarkable success story. *The Firm* is a professional services firm who recognised innovation as a pathway to bring greater ingenuity and efficiency to the company's market performance with clients. It started a national innovation program in 2004 to encourage people to explore innovative ways of thinking and applying different perspectives to solving business issues. More than 2,000 employees regularly collaborate on the in-house social media channel, with an equal number attending service line and national client-focused idea cafés and workshops aimed at complex problem-solving and creating opportunities in the marketplace. The premise is that everyone is an innovator.

As of 2009, with some 80% of the firm's employees actively participating in the innovation program, more than 20% of the firm's revenue is generated through new or substantially different businesses and service offerings. The innovation program is regarded as highly profitable due to its return on investment of more than 300%. Having successfully set up the innovation program, the firm was awarded a CFO Magazine's Accounting Services Firm of the Year Award in 2006 and 2008 with the commitment to innovation noted as a differentiating feature, and was named 'most innovative firm' in Australia by another major business-oriented magazine (2005).

For the empirical data collection, a triangulation (method) data collection method was applied to maximize the internal validity of the study. The data collection method chosen included a mix of in-depth personal interviews with key people within the company, use of confidential proprietary internal material provided by the firm,

promotional material (including internet and marketing collateral) and personal experience (Blaxter et al., 1996). A series of 3 interviews were undertaken whilst the personal knowledge of two of the authors, one a former consultant within the Innovation team, was accessed. Those interviewed included a partner of the Innovation Group, a Director who oversaw the innovation program's development and a further Director associated with the implementation of some of the activities described in this paper. Candidates were selected based upon their high level of knowledge of the innovation program. The interviews were transcribed and checked by the interviewee for accuracy. The notes from the interviews were manually synthesized and then reviewed by the interviewees again for accuracy.

The ADKAR model and its success factors outlined in section two provided the framework for data collection and analysis. Interviewees were provided information about the ADKAR model prior to the interviews, and the interviewees supported the process of data collection providing evidence of progress, either verbal or documented.

Following a call for great transparency and personal disclosure of possible Author-bias and involvement with the organisation at the centre of the study (Dyer and Singh, 1998), it should be noted that two of the co-authors worked with the case organisation in the past. The first author spent some time working within the case organisation in order to create a greater depth of understanding of the case organisation. The intimate knowledge created through these associations allows for a much greater depth of analysis and explanation which would have otherwise not been possible. The first author has held the responsibility of challenging claims made by the case organisation and ensuring objectivity. Additionally, where possible, third-party validation of claims has been sought to underpin the papers objectivity. It is acknowledged that a limitation of this paper could be the potential bias resulting from these associations, however it is believed that this approach has allowed the paper to reach greater levels of depth of information and therefore use in practical implementation.

Table 2. Research design overview

Attribute	**Characteristic(s)**
Research strategy	Case study
Aim of the case study	Provide description
Type of case study	Qualitative
Target population	Large enterprises
Industry sector	Professional services
Case selection strategy	Extreme/deviant cases
Data sources	Intranet and promotion material, non-structured interviews with key people within the company studied as well as personal experiences

The following section now outlines the firm's innovation program and takes a closer look at the structures set up, the strategies applied and the practical activities undertaken.

5 The case of a large professional services firm

5.1 Introduction to the firm's innovation program

The firm studied is part of a larger corporation, a globally connected network of firms in more than 140 countries employing nearly 200,000 professionals. The firm employs more than 4,500 people who provide audit, tax, consulting, and financial advisory services to public and private clients. In 2009, *the firm* achieved revenue growth of 11 per cent in spite of the toughest trading conditions in decades after maintaining growth rates of more than 20 per cent for the previous three years. *The firm*'s commitment to innovation has supported this growth through the development of new products and services. Known as an employer of choice for its innovative human resources programs, the firm is committed to helping its clients and people excel. *The firm's* professionals are dedicated to strengthening corporate responsibility, building public trust, and making a positive impact in their communities.

Nine years ago, *the firm* recognized the importance of creating and sustaining an innovation environment in order to archive its ambitious growth plans. Regarding this, the biggest challenge was to transform the vague concept of innovation into a solid activity for its partners (joint owners and most senior position in *the firm*), employees (in order of seniority: director, manager, consultant/analyst, graduate), and other stakeholders (e.g. clients, industry groups, vendors, universities, etc.). Apart from communicating the significance of innovation regarding *the firm*'s overall business and growth strategy, it was seen as crucial to create a sustainable work environment which encourages stakeholders to actively participate in and contribute to innovation.

Since 2004, *the firm* has been addressing this challenge with its national innovation program, which sought to transform the work environment at the deepest level. The central premise of the program was that "everyone has the right to innovate." This means that everyone in the organisation must have permission and encouragement to "play in the innovation space". The innovation program educates and supports stakeholders who then generate and develop ideas on how to improve internal processes or service delivery to clients, as well as creating ideas for new products and services to bring to market. As a structured and comprehensive business process covering targets, funding, resources and accountability, the program covers the whole innovation process from helping people to generate ideas to the successful launch of disruptive and breakthrough innovations.

The firm's initial strategic vision and approach was based on the framework presented in figure 3:

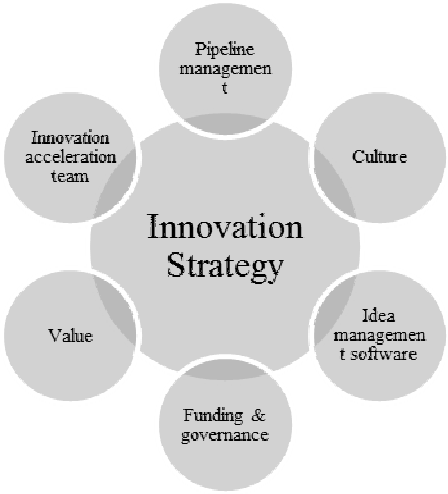

Fig. 3. The first innovation framework

Innovation Strategy: The heart of *the firm*'s framework is the innovation strategy. Defining the role of innovation within the organisation, the innovation strategy provides the context and guiding principles for the design, implementation and operation of the innovation program in alignment to the overall business or growth strategy. By determining the program's goals and objectives, its boundaries, and its measures of success, the innovation strategy enables organisations to clarify the vague and intangible concept of innovation. Most importantly, the innovation strategy is aligned to *the firm*'s overall business strategy and has a strong commitment by the CEO/board.

Culture: The innovation program aims to create an innovative culture, and to embed and continually improve an innovation capability of an organisation. The objective is to educate employees (ability), and, most notably, to encourage and maintain their interest and engagement in the long run (willingness). Winning over the hearts and minds is seen as a key to drive the quantity as well as quality of ideas, and finally to extract value from the program. In order to do so, *the firm* uses strong communication, networking activities, a Reward & Recognition program and relates the innovation program to the company's business culture, which is shaped by *the firm*'s award winning communication campaign.

Idea management software: The firm's idea management software is a web based idea management solution providing the primary contact point for employees to interact with the innovation program and with each other. The centrepiece of the software is the ability to collaboratively improve submitted ideas in order to extract the maximal value at the end. However, the interaction is not limited to employees; rather the idea management software is aligned with the other building blocks of the framework and supports the whole innovation process, including idea generation, idea capture, idea review by an innovation council, idea development and launch.

Funding & Governance: Effective governance is vital to achieve the defined goals and objectives, and to manage funding in an appropriative manner. The firm has

employed a multi-tiered governance structure, including an Innovation Executive to direct the program at the strategic level, and two Innovation Councils, which perform the more tactical role of filtering ideas. Financial and other resources have to be identified, approved and tracked to set up and manage a program respectively to develop and implement ideas. Furthermore, long-term oriented management and operating structures need to be developed as the backbone of the program.

Value: In order to reach the program's objectives, and to ensure that the program contributes to the overall business and growth strategy, specific tangible and intangible targets have to be defined. These targets, working as both goals and measures, ensure in conjunction with costs and benefits tracking, a target-oriented execution of the program.

Innovation Acceleration Team: To ensure that business as usual does not get in the way of high potential ideas with a crucial speed to market, a specialized team accelerates the development and implementation of time-critical ideas. This team, focused on maximizing and capturing value of an idea, has expertise in intellectual property (IP) management, rapid prototyping, business case development and go to market strategies.

Pipeline Management: The program's pipeline management component defines criteria, tools and templates to provide a structured process for moving an idea from its generation to launch. Different stage gates (raw idea, active concept, funded prototype, and market expansion) ensure to drive the quality through the program, and hence to extract the maximal value of an idea.

Due to its internal success, *the firm* took the strategic approach of its innovation program to market and has successfully applied the program to a number of clients across varied industries, e.g. a large bank in Australia, a leading general insurer, one of the world's leading commercial real estate services and money management firms, and one of the world's largest news media companies.

Over the past nine years, *the firm*'s innovation program has gone through both minor and major changes as part of an overall continuous improvement cycle. There have been four distinct points at which the direction of the program changed. Not surprisingly, these changes correspond with changes in the program's leadership and governance structures:

1. Inception (2004) – the program was run by a small team comprising one director, a part time communication director and manager. There was a small provision for operational funding with the focus on communication and socialising the concept of innovation across *the firm* as a whole. Funding for innovation initiatives was appropriated and approved on a case-by-case basis by an innovation council and *the firm* executive.
2. Integration and Acceleration (2006) – the program was aligned and integrated with the mainstream investment and growth function of *the firm* and a dedicated pool of funding was allocated. Financial, operational, governance and project management processes were established. In addition, a team of innovation specialists were assembled to help incubate and accelerate ideas. This resulted in the creation of a new business unit (focussing on the digital business side) and several spin-off companies.

3. Innovating Innovation (2008) – To continue to drive innovation deeper into each service line so that innovation could be confidently regarded as embedded in its DNA, *the firm* developed metrics and KPIs to benchmark and monitor cultural impacts and portfolio performance. Early results highlighted the need to enhance ways for staff members to collaborate across its national offices, industry groups and service lines. A new ideation and education platform was rolled out along with social media tools including Yammer. The innovation team of four fulltime and two part-time members including two directors and a manager, facilitated departmental and 'top gun' ideation sessions as well as firm-wide initiatives. To further test the assumptions, experiments with new types of funding models, ideation techniques, execution strategies and governance structures were conducted and the resulting impacts were analysed using the new metrics.
4. Re-vision (2010) – These experiments, *the firm*'s successes and track record, and the economic marketplace led to identifying innovation as one of the five pillars of *the firm*'s 2015 business strategy. To ensure tight alignment of innovation strategy with *the firm*'s organic development strategy, funding and governance structures have been adjusted and strengthened. The more mature innovation program of 2010 will now develop into three more distinct functional components comprising a:
    - strategic radar for identifying innovation opportunities
    - culture and capability development and
    - portfolio management.

5.2 Applying the theoretical framework to *the firm*'s innovation program - Phases of change project explained

Considering that *the firm* provides services in the areas of audit, assurance and advisory, tax, corporate finance and consulting mainly to large and middle sized corporate and government organisations, it perhaps would not be considered to be a typical environment for innovation. Resistance to change and the long time-frame to create momentum for the innovation program across *the firm* are common challenges faced by large firms when seeking to embark on long term cultural change. Owing to the nature of the industry in which *the firm* competes, with few employees familiar with innovation, *the firm* needed to overcome a lack of understanding and trust of innovation and its ability to provide the desired growth levels. As a first step, this required the creation of a structure (Innovation Framework), strategies and activities that would drive this change. This created a true change management challenge that required a multi-faceted change management approach with a robust communication strategy at its core.

The firm's innovation program will now be evaluated using the ADKAR change management model. Firstly the phases of a change project will be analysed.

Business need

The initiative to develop innovation within *the firm* was as a pathway to bringing greater ingenuity and integration to their market performance with clients. Further, the commitment to a long-term strategic focus of creating a culture of innovation was

seen as something that could potentially offer sustainable growth for the company. The primary business need therefore was determined to be the creation of growth through innovation particularly focused on improving current business and creating new business streams designed to create new revenue. This was recognised at the top of the organisation, was pushed by *the firm*'s executive and supported by partners nationwide.

The firm's ranking amongst the 'big 4' national professional services firms was a point continually communicated internally with the desire to 'move up the ladder' being emphasised. Being a professional services firm that deals primarily with finance, the communication of current market position as well as growth objectives was emphasised to staff using financial data wherever possible. The key message was: *the firm* would not achieve desired growth (20% growth targets) without innovating into new services. This message was communicated and reinforced by partners and directors in a coordinated 'sell' program to employees.

Concept and design

The firm set out to transform the work environment at the deepest level, to essentially change *the firm*'s DNA. This required a comprehensive strategy, accompanying structure and subsequent activities in an innovation program framework in order to achieve this objective.

The program incorporates five strategic elements that are integral to ensuring sustained success (compare also section 5.1):

1. Defining the strategy for innovation and its performance based outcomes. This was about aligning their innovation goals with their overall business strategy and seeking to embed a sustainable innovative capability into the organisation.
2. Building a sustained process for translating ideas into value consistently and over time. Redesign processes to define and refine the idea pipeline. This included decisions around which criteria would be used for progressing ideas through to the next stage, how would ideas be prioritised, and how they could be funded.
3. Implementing a governance and funding model for supporting and delivering innovation.
4. Driving a cultural change and communications plan for engaging, educating and rewarding staff (to be explained in greater detail in section 5.5).
5. Implementing the value based tools and templates to measure and report through on innovation to monitor and manage the innovation process.

Implementation

Implementation of *the firm*'s innovation program began in mid-2004 with the mentality that 'everyone is an innovator' and so employees were empowered to seek new innovative solutions for their customer's business problems. Innovation at *the firm* starts from inside the company and is firmly based on a culture that encourages people to explore innovative ways of thinking and different perspectives for solving business issues. As such, capturing the 'hearts and minds' of *the firm*'s employees was seen to be crucial in the success of the program.

Crucial to the implementation phase was the involvement of volunteers ('many voices

and hands make lighter work'). Staff members had to be willing to contribute to a process of personal and professional change. The foundation for building innovation capability inside *the firm* was the formation of a team comprising partners and directors who had gone through workshops to gain their support for the program. This team, before the commencement of the innovation program involved representatives from all areas of *the firm*. The workshops also seeded the network of volunteers known as Innovation Champions. The voluntary community of innovation mentors draws from across *the firm*'s industry groups and regions, and help to inspire and motivate employees to participate in the process. Champions support employees to generate innovative ideas and participate in a process designed to select winning ideas and then develop them into business cases.

The firm strategically involved many levels of involvement but focused its efforts across three paradigms with objectives within each:

1. The Individual
    - Recognising individuality
    - Encouraging internal entrepreneurs
    - Inviting the individual to contribute and to make a difference
    - Attracting talented individuals
    - Fostering passionate entrepreneurship
    - Pushing innovation creates an environment where talented individuals choose to work there and so assist recruitment objectives
2. The Team
    - Using the power of combining individual intellect and talent across the firm
    - Forming teams that cut across hierarchies and business units
    - Creating 'tribes' of participants who work together
3. The Organisational level
    - Redefining traditional relationships between customer, supplier and even competitor
    - Pushing the boundary of the organisation to blur the boundaries between organisation, networks and supply chains
    - Bringing in other organisations to create a network

Post-implementation

The innovation program is an on-going concern where continual improvement and fine-tuning is sought. The firm's commitment to the creation of an innovative environment is seen in their continued investment in the program with human and capital resources. Their commitment to this corporate direction requires them to continually seek a better return on investment from the program and thus involves continued dedication.

Most of the activities outlined in the change management process above are conducted within *the firm* in the continuation of the innovation. This further reinforces the commitment to innovation within the organisation.

New ways to engage and motivate employees are continually sought and are achieved

through innovation promotional campaigns, recognition of innovation activities in performance reviews and being an ever-present issue raised in team meeting and appearing in the inbox and intranet of employees.

Post-implementation activities can also be seen in the continual monitoring of *the firm*'s idea pipeline through the idea management software by the Innovation team and Executive as well as the objective to recruit those with proven talent in innovation or are keen to work in an innovative environment.

There has also been a process of continuous improvement based on feedback obtained from participants in the program. Some examples of the minor post-implementation changes include;

- New types of workshops and ideation sessions, such as morning "EyeOpener" sessions that introduce edgy new thinking (e.g. Serious Games, Social Media, Data Visualisation)
- An upgrade of the idea management software to the Innovation Academy – a platform that encourages learning and collaboration as part of the ideation process
- The rollout of social media tools such as Yammer to promote further internal communication and collaboration
- Changes in the funding and project management approaches – such as the creation of "microfunds" which shorten the time needed to get funding and eliminate bureaucracy from the approval process
- Helping teams that receive funding develop rapid prototyping skills
- Reward programs based on collaboration and participation metrics
- Development of a "FastTrack Innovation Challenge" program which takes students from top Australian universities through a semester-long journey from ideation through prototyping to business case.

Furthermore, the strategic context for the program has been refined and aligned with *the firm* wide strategy to drive from being a vendor to becoming an advisor, but ultimately acting as a shaper of business and policy. Figure 4 shows the articulation of the central "strategy" circle within the Innovation Framework discussed at the start of the section.

Innovating in our country	**Shaper of innovative vision** Creating advantage and eminence through supporting positive transformation of our nation's innovation culture.
Innovating for our clients	**Advisor with innovative solutions** Demonstrating a consistent ability to think more creatively about our clients' issues.
Innovating for our firm	**Vendor of innovative services** Becoming more relevant to our clients by consistently providing unique, inspiring and market leading services.

Fig. 4. The firm's Innovation Strategy

5.3 Applying the theoretical framework to *the firm*'s innovation program -Phases of change for employees explained

The source of the change within *the firm* to a more innovative culture was centred on the need to engage and involve staff in a fun, interesting and hand-on way. The innovation program's premise is that 'everyone is an innovator'. In *the firm* they like to say that the company gives its employees permission to play in the innovation space.

The process of innovate change was considered such a high priority that it is a Key Performance Indicator for all employees. A thousand employees attended workshops during the initial phase of the program to develop innovation skills whilst a system of rewards and recognition celebrate their achievements.

In respect to the 'phases of change for stakeholders' axis of the ADKAR model, the following activities were observes:

Awareness

Top-level partner ownership was seen as critical for the change to an innovative culture: "Innovation starts at the top," said the Head of Innovation and Managing Partner of Consulting in the Asia Pacific region. "It is important that the leaders in the business are committed and understand how critical innovation is to increasing the bottom line and competitiveness in the marketplace. With targets in mind this 'vision' needs to be consistently communicated across the whole business with everyone's role clearly outlined".

The vision for the innovation program was created and is subsequently updated annually at the Partner and Director annual forum therefore engaging all senior within *the firm*. The firm embarked on an all-inclusive innovation training program for its top leaders to clearly communicate what innovation is, and is not.

Desire

Desire to be part of the program was driven through a number of key initiatives. The creation of firm-wide innovation 'champions' to encourage and support participation and keep up the momentum in developing ideas and getting them to market was seen as crucial for the creation of a desire to change.

The firm engaged an 'internal sell' to introduce the innovation concept to employees and the need for *the firm* to become more innovative to achieve growth targets. This was achieved through presence at monthly meetings, posting articles of *the firm*'s intranet, novel promotions and competitions as well as the launch of the Innovation Week concept. It was also achieved through the fact that the senders of the messages on innovation within *the firm* came from the very top (executive level) and partners. The active participation in the program by partners was an example of leading from the front to which many of *the firm*'s employees willingly followed.

"It is important as a manager to provide the senior sponsorship necessary to drive ideas through organisational barriers," says the consulting director and partner of *the firm*.

Further, by recognising innovation performance by individuals in their performance review, *the firm* gave employees the incentive to involve themselves in their program.

Other mechanisms for the recognition of 'early adopters' of the innovation program were also created. These will be elaborated on further in section 5.5.

Knowledge

The establishment of a knowledge-base in respect to innovation was required to ensure employees felt empowered to be involved in the program. The emphasis firstly was to build a knowledge base within individuals. Individuals were then also engaged using teams that allowed the mixing of employees across different business units in order to create a shared learning environment. Some of the knowledge building activities included:

- Innovation training courses were made available to employees at all levels of the organisation
- Individuals were given a one week 'innovation immersion' through Innovation Week activities. This included seminars on innovation, speakers from experienced innovators and hands-on involvement in innovation activities
- Articles on innovation were posted on internally accessed intranet
- Specific coaching and/ or mentoring was provided to those submitting ideas through the Innovation Acceleration Team

Ability

A further ingredient seen as crucial for acceptance was to have the required resources available to the innovation program. The resources were in the form of:

- Financial resources – not just in terms of funding the program's management but also in terms of funding the ideas through either dedication of chargeable hours or indeed through financial investment in a business concept.
- Tools and materials – These elements were crucial for facilitating the creation and development of ideas which were primarily managed through the 'innovation zone'. The idea management software created an online (although internal) access point for inputting, developing and collaborating on ideas.
- Access to mentors and experts – 'Entrepreneurs in residence' and Innovation Acceleration Team provided personal coaching to selected employees in order to increase their innovation abilities.
- Time – Through the creation of an innovation week, the firm prioritised time for employees to focus their efforts on innovation. Further, employees were given small challenges by the CEO to complete during work hours.

In the promotion of the innovation program, there was an emphasis placed on utilising fun and interesting methods for encouraging participation in the innovation program. The fear of change and the actual process of innovation was broken down through inclusive, hands-on activities designed to engage employees.

Reinforcement

The firm ensured that reward and recognition was given for participation in the innovation program as well as for relevant innovation successes. This included:

1. Recognition for idea contributions
    - Partner & staff KPI of 2 idea contributions per annum
    - Idea contributors recognised at mid-year and end-of-year review times
2. Rewards for approved ideas
    - Quarterly award winners for top 3 ideas voted by Innovation Council members ($250 Red Balloon gift voucher)
    - Annual award winner ($5,000 toward a course of winner's choice) announced at Partners' Conference
    - Recognition for Innovation Champions
    - Annual award for greatest volunteer announced at annual Partners' Conference
    - Innovator of the Year Award announced at annual Partners' Conference.

A transparent system for accountability was established in the creation of the idea management software. This enabled *the firm* to track who had participated in the program and how often. Those who were not involving themselves in the innovation program through the Innovation Week events or through the idea management software were encouraged by partners to participate through team meetings, personal emails and personal attendance at events.

Improvements to the program were, and still are, continually sought as are new activities and methods to get employees in the program. A process of experimentation, rework and improvement is undertaken to fine tune the program. Further, those involved in the innovation groups are continually rotated to keep fresh faces and ideas in the process.

5.4 Applying the theoretical framework to *the firm*'s program - Structure of involvement

The voluntary Innovation Groups were used as a method for getting acceptance and involvement from employees across *the firm*. The groups involved key partners and directors within *the firm* as well as inviting relevant external parties into the innovation forum and included:

- Innovation Executive - 5 member Steering committee for innovation
- Innovation Team - 6 resources devoted to program strategy, idea generation, idea execution, communications, R&R, performance, learning
- Innovation Council - 20 Partners who review new ideas and sponsor approved ideas
- Innovation Champions - 30 volunteers from service lines and geographies who promote innovation at local level
- Innovation Acceleration Team - 3 resources providing specialist skills in market analysis, project management and technical development.

Using the ADKAR model the following figure defines the involvement of those within the organisation at the various stages of the change process for stakeholders (the darker the background color, the higher the involvement).

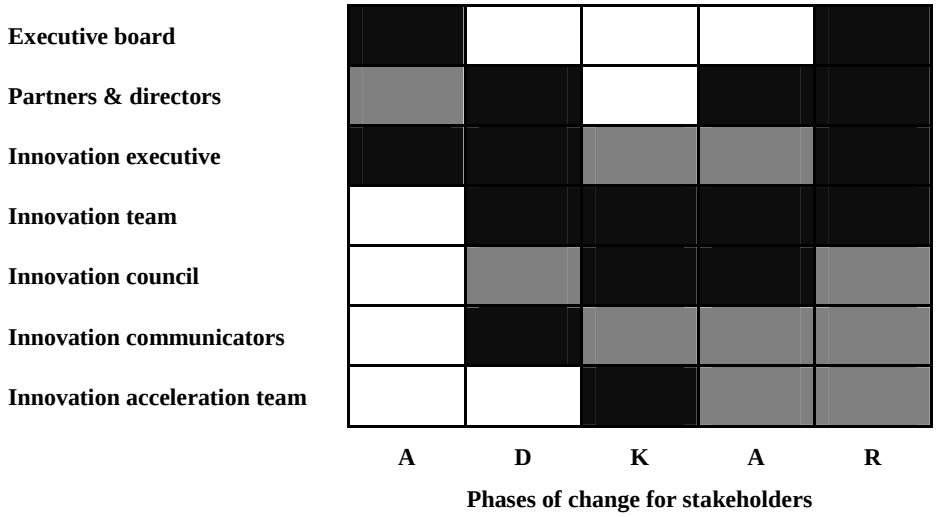

Fig. 5. Involvement of *the firm*'s partners and innovation staff

5.5 Specific communication activities undertaken in the change management process

Internal promotional activities

The firm undertakes extensive internal and external communication for its innovation program to ensure acceptance, garner involvement and win support and reinforce the innovation agenda to become part of the company DNA.

Internal innovation campaigns

The 'Innovation Week' (innovation challenge and ideas festival) is the major vehicle for the promotion of innovation within *the firm*. Innovation weeks are run 3-4 times throughout the year with client as well as internal challenges. Innovation is promoted to all employees through regular events, competitions and integration in the performance review process. In the spirit of creative play, the CEO issues employees with various competitive challenges such as a "100-day race" broken into 20-day laps: every 20 days the staff had to do something innovative with a client and come back and record the story. Further activities during the week include:

- Breakthrough Cafes and Innovation Lounges – Informal environments to 'play in the innovation space'
- Innovation workshops
- Group problem solving around specific themes
- Presentations from innovators
- Competitions for idea submission.

The Innovation Team has also run campaigns around particular themes deemed to be significant future problems confronting society e.g. a "Sustainability Week" was launched in 2007, where 500 new ideas relating to sustainability were submitted to the zone in one week. A program was also run for an international air carrier within *the firm* to obtain relevant ideas for their business improvement.

"EyeOpener" sessions are also run every month where internal and external innovative leaders are invited to explore cutting edge topics. These events are invite-only, with invitations given to top innovators and participators in firm-wide events and collaboration networks like Yammer.

Reward & recognition

Reward & Recognition is tied to innovation. Performance reviews include consideration of innovation program participation. Reward within *the firm* is structured as mentioned in the reinforcement section in section 5.3.

Internal publications

The firm's internal publications ensure that innovation themes are regularly seen by employees. The publications include: an internal newsletter published monthly with specific success stories; Intranet - Innovation success stories are regularly published on *the firm*'s intranet. In 2009 the Innovation Academy was launched, which provides regularly updated video content and blogs on innovation topics.

Idea management software

The firm's idea management software supports the entire program to funnel ideas through an idea pipeline. The firm created an innovation tool that would allow staff to submit ideas, collaborate on them and track their progress in a transparent way. The software encourages sharing of ideas and 'innovation lab' atmosphere where the power of many was leveraged and provides suggestion for improvement of ideas. In 2009 the software tool became a part of the Innovation Academy and the software was updated to take advantage of web 2.0 technology and enhanced collaboration.

External promotional activities

The firm also committed considerable time to promoting its commitment to innovation as a further means to stimulating not only internal interest in the innovation program but also external interest. This had the benefit of attracting interest from current and potential clients as well as attracting talent to *the firm*. Like most professional services firms, *the firm* is susceptible to a high employee turnover so *the firm*'s commitment to innovation is seen as point of differentiation in attracting employees. External interest in the program was fostered to further reinforce internal interest and involvement.

External publications (media releases, white papers and newsletters)

- Corporate brochures promoting the firm's innovation capabilities
- Many media releases to major newspapers, magazines and other publications
- A bi-monthly electronic publication focusing on innovation (external newsletter)
- White paper publications.

Innovation leadership

The firm seeks to take a leading role in business circles in respect to the topic of innovation and external recognition of efforts through a number of methods:

- Innovation partners and directors are sought after presenters in government and business circles for conferences, summits and roundtables
- The program is frequently used as a business case study by business foundations, innovative think tanks and government reports on innovation
- The innovation leadership is also regularly profiled in major media in articles about innovation
- The firm frequently facilitates summits on innovation and future topic
- The program resp. the firm won various awards on firm innovation.

Sponsorships

The firm also engages in the following sponsorships to further sustain its commitment to innovation:

- Australian Innovation Festival 2005, 2006, 2007, 2008, 2009
- Australian Business Foundation
- Innovation Leadership Summit – in conjunction with University of Queensland, Business Review Weekly
- Australian Innovation Leadership luncheon series 2006-2010.

6 Discussion

In this paper, it has been sought to bring clarity to the difficult topic of how to affect real change within a large organisation in order to create an innovative environment. Using the case study of a large professional services firm, and their transformation using a combination of structure, strategies and activities, by itself creates a useful insight into a 'best practice model'.

It has been explained that simply using communication methods by themselves may not have been enough to create significant innovation change within *the firm*. However by using communication as the centre-piece for an all-encompassing change project, one which combined a 'change project process' with a specific focus on the 'phases of change for employees', could provide an appropriate strategic framework in an innovation setting.

In respect to how a large organisation could create a more innovative environment using a strategic innovation program, some generalised models have been created below based upon the experience of *the firm*, for use by other practitioners and to create a point of discussion.

The question of "*what process could be followed?*'

Using the case study, the following model has been developed to highlight the nature of the change management process in respect to the creation of an innovation environment. It reflects, like the ADKAR model itself, the need to develop the X and Y axis of the ADKAR model simultaneously. That is, to work through the phases of change of innovation project at the same time as advancing through the phases of

change for stakeholders.

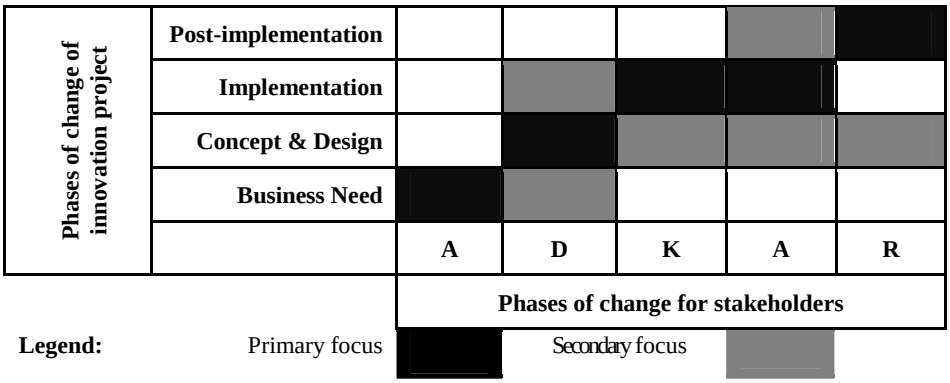

Fig. 6. Change process

The question of '*who could be involved?*'

The following model highlights the possible involvement of key players within the innovation change management process.

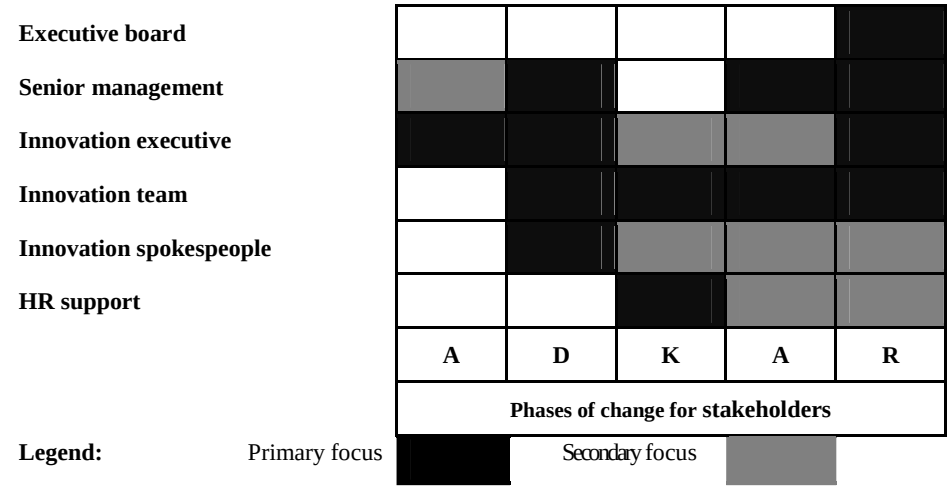

Fig. 7. Key player involvement

Answering the question of '*how might the innovation initiative work in reality?*'

Owing to the need to continually build interest and involvement in the program and the need to seek continual improvement, the phases of the innovation change project need to be continually revisited. This works in a cyclical rotation where the program regularly seeks to move employees through the ADKAR phases of change for employees. This is especially true for those stakeholders new to the organisation.

Today, the "permission to innovate" is well established within *the firm*'s core culture. Nearly all cultural programs activities include some aspect of innovation. The next challenge is to raise the bar. The firm's executive now believes everyone has not just the right, but the "responsibility to innovate." This means that simply conducting "business as usual" is unacceptable. The firm's partners and employees are being

asked to constantly challenge the assumptions behind current offerings and look for un-addressed needs that clients are facing. Their objective is to develop relevant, qualified problems that require innovative solutions. These problems are then presented as challenges to *the firm* as well as to a wider network of innovators, with the ultimate goal of generating ideas that are directly align with *the firm*'s strategic priorities and market needs.

Changing the culture from "right to innovate" to "responsibility to innovate" will require a full ADKAR cycle as well. At the time of writing *the firm* is entering the Desire phase – awareness has been generated through nearly a year of internal campaigns and conversations; now partners need to desire the change. This is being accomplished by setting a central KPI for service lines to generate 30% of their revenue from new or substantially different offerings. This KPI simply cannot be achieved without a sustained commitment to innovation. The revision of the innovation strategy is being structured to ensure that *the firm* will have the knowledge and ability to innovate at the level required to achieve that target. Reinforcement will occur when bonuses and profit shares are tied to performance against the 30% target.

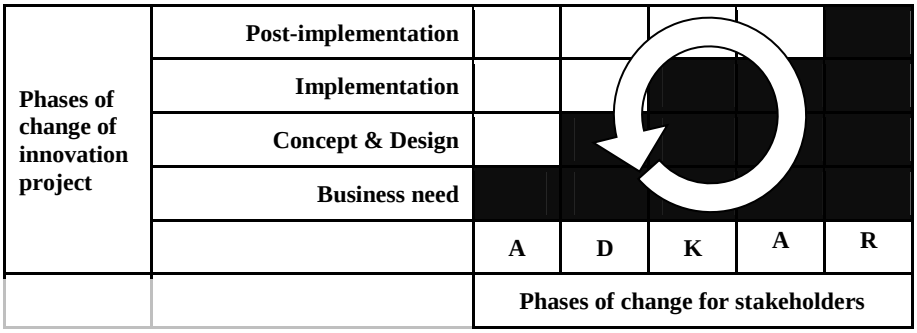

Fig. 8. Continuous innovation program improvement

7 Conclusion

This article considered the question of how large enterprises can address the need for innovative products, services, processes and business models by creating a more innovative organisational environment. The novel contribution of this paper is in the use of the ADKAR change management model in order to establish an innovation program within a large organisation. The ADKAR model allows strategic consideration of not only how an innovation environment can be created in a project sense but also how change can be affected at the stakeholder level with particular regard to marketing and communication elements. Innovation, it is said, occurs at intersections of people, industries, competencies and cultures. This paper sought to intersect a strategic change management model with the introduction of an innovation program within a large organisation. This intersection sought to create a new perspective in the process of innovative change within large organisations.

The paper sought also to highlight practical steps and activities as used by *the firm* in their quest for altering their firm's culture by instituting a firm-wide innovation

program to create a more generic and useable model. In detailing the successful innovation program of this particular firm and the steps taken to ensure key stakeholder acceptance and participation, the reader will receive practical relevant knowledge. It finally sought to provide a framework for the management of the entire process of innovation organisation change.

Managerial and theoretical implications. A *managerial implication* of this paper is that developing the culture of an organisation to be more innovative could benefit from a change management approach. By mapping the development of a successful example, this paper illustrates that understanding the innovation process, in combination with an understanding of change management can result in higher success. The paper also illustrates that multiple levels of the organisation need to be involved in this process to ensure successful transition. Finally, proper communication addressing different topics during the change management process supports the change process. *For theory*, the implications of the paper are that there could be a relationship between change management and innovation development of organisations meaning that change management literature can play an influential role in innovation studies. In this context, the innovation process therefore becomes more prominent in building innovation literature.

Limitations. While this paper provides significant insights into organisational innovation, change and growth, the findings should be considered in the light of two significant limitations. First, it has to be kept in mind that the findings are based on one single case study. Second, a potential author-bias resulting from the authors' (prior) involvement in the organisation has to be acknowledged. Therefore, more rigorous testing is needed to confirm or disconfirm the findings presented (validity and generalisability).

Future research. Further recommendations for future research are as follows: First, future research is needed to determine the transferability of the innovation program shown to SMEs, other industry sectors, or other countries. Second, future research is required in order to investigate whether or not, and if so, how the various internal and external stakeholders have to be approached differently. Lastly, investigating further successful innovation programs and outlining their specific structures, strategies and activities would be of high value for enlarging the knowledge base on how to generate organisational growth through innovation.

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Creating cultures of sustainable innovation

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Abstract. Sustainability has become one the main drivers of innovation and many regions in the world aim to transform into a 'sustainable innovation region'. Culture is an essential element of the innovation environment in sustainable innovation policies. This article discusses recent insights in the theoretical and empirical foundation of innovation policies aimed at developing 'cultures of sustainable innovation'. A multidisciplinary approach based on the dilemma paradigm of enquiry is used to develop a dynamic framework on how to foster sustainable innovation. The approach is applied in an assessment of the sustainable innovation culture in two regions: Silicon Valley and Southeast Netherlands. It is concluded that Regional Innovation Systems can be assessed by evaluating to what extent a dynamic balance is established on each of the innovation culture dilemmas. However, copying 'success formulas' for sustainable innovation from other regions is impossible. The dynamic balance depends on history and culture of the region and the continuous interaction with the external environment.

Keywords. Innovation, sustainable development, regional culture, cultural geography, policy, regions in The Netherlands

1 Introduction

Many aspiring innovative regions have tried to copy the success of Silicon Valley, often replicating the magic word 'Valley' in their regional 'brand'. Even a small country like The Netherlands has a Seed Valley, Health Valley, Food Valley, Energy Valley, Media Valley and Maintenance Valley. The recipe for regional innovation policies seems to be to emulate the success factors of Silicon Valley as an innovative region as reported in the extensive literature on the region, e.g. proximity, collaboration and sharing knowledge, high quality of life environment, entrepreneurial mindset and the presence of excellent research universities (Kenney, 2000; Lee et al., 2000; Wang and Horowitt, 2012). In recent years many regional innovation policies have failed with as a result skepticism about policies aimed at fostering innovation. Therefore, it is one of the main challenges in research of innovation to develop a framework underpinning innovation policies by a theoretically and empirically founded vision on the innovation process.

Innovation theory has shifted over time from the linear view on innovation (a straight line from science and technology to innovation) to a non-linear and more dynamic view. The latter requires taking into account interactions between a range of factors in the wider innovation system, such as entrepreneurship, diversity of ideas, cooperation, marketing, design, attracting and developing human capital, governance and the organization of innovation. It is getting increasingly important to incorporate

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conditions of sustainability in innovation theory. Environmental changes and other sustainability issues act as a catalyst to innovation and it is even argued that sustainability has become the key driver for innovation (Nidumolu, 2009). 'Sustainable innovation' is not just about generating company profits, it aims to benefit the company as well as its stakeholders by finding a balance between '*People, Planet and Profit*'. Innovative companies need to be able to recognize societal and environmental challenges and to find creative ways to address these challenges in such a way that it provides long term value for society (people), long term value for the environment (planet), and sustainable business (profit).

A multidisciplinary approach is critically important to develop successful innovation policies (Boekema et al., 2000, p.81). Prud'homme van Reine (2011), building further on Cooke (2007), argues that regional innovation policies need to address:

The socio-cultural environment: identity and cosmopolitanism, attracting talented human capital, sustainable development,

The economic environment: stability and change in clusters and value chains, technological development and interaction with markets and end users, cooperative and competitive attitudes,

- The institutional environment: knowledge infrastructure, governance, financial infrastructure.

In this article a multidisciplinary approach based on the dilemma paradigm of enquiry will be used to develop a framework on how to foster sustainable innovation. Following Jorna et al. (2004), the concept 'sustainable innovation' will be used here in a wider context than just innovation aimed at developing sustainable services, products and production/manufacturing processes. It also encompasses organizing innovation processes in such a way that sustainability becomes a basic attitude, or in other words, creating a sustainable innovation culture (Hautamäki, 2010).

2 Innovation dilemmas and regional innovation systems

The innovation dilemma approach (Prud'homme van Reine and Dankbaar, 2009, 2011a, 2011b) is a promising framework to understand innovation processes because it acknowledges the dynamics of the innovation process and allows for addressing interactions between a wide range of factors in the innovation system. In the innovation dilemma approach, creating innovation cultures is seen as a continuous process of finding a dynamic balance in a number of 'fields of tension', which can be described by innovation dilemmas. Tensions exist e.g. in generating ideas, in interactions between actors in the innovation process, in attracting talent, in organizing innovation, in governance of innovation, in short versus long time perspectives and change versus continuity. The innovation dilemmas can be derived from an analysis of the fundamental cultural dilemmas identified in models to assess national, regional and corporate cultures (Hampden-Turner and Trompenaars, 2000; Trompenaars and Prud'homme van Reine, 2004; Trompenaars and Hampden-Turner, 2010). In the dilemma model of culture, corporate cultures, regional cultures and national cultures are characterized by how they handle a number of fundamental cultural dilemmas. The cultural dilemmas can be translated to nine innovation culture

dilemmas at the level of corporate cultures (Prud'homme van Reine and Dankbaar, 2009), where they show up in the practices of innovative companies, e.g. in how Toyota manages contradictions in its innovation process (Takeuchi et al., 2008) and at the level of regional cultures (Prud'homme van Reine and Dankbaar, 2011a) where the innovation dilemmas show up in how various stakeholders try to balance tensions in regional innovation systems (Prud'homme van Reine and Dankbaar, 2011b). This article focuses on regional innovation cultures. The following nine dilemmas have been identified as a comprehensive set to characterize regional innovation cultures (Prud'homme van Reine and Dankbaar, 2011b):

The dilemma in generating ideas for innovative products and services: technology/knowledge driven versus user/market driven innovation. It can be seen in the tension between innovation based on recognition of technical potential versus involvement of 'lead users' and 'customer innovators' in the development of innovative custom products (Thomke and Von Hippel, 2002).

The dilemma in the interaction between innovative companies: open innovation in cooperative, trust-based relationships versus closed innovation in competitive relationships. It can be seen in the tension between proximity to ensure effective communication and common understanding and distance to avoid lock-in (Boschma and Frenken, 2011).

The dilemma of creativity versus control: regional innovation led by (often small) creative companies versus regional innovation led by (often large) process driven companies. It can be seen in the tension between dominance of large, resourceful 'anchor' firms (Agrawal and Cockburn, 2003) versus small firms which can be more risk taking, pioneering and fast moving (Florida and Tinagli, 2004).

The dilemma in the regional knowledge infrastructure: focus on fundamental research versus focus on application oriented R&D and entrepreneurial activities. It can be seen back in the tension that is often described as 'the knowledge paradox' (Boekema et al., 2000): high investment in good quality fundamental research, but insufficient economic returns.

The dilemma in attracting innovative knowledge workers to a region: high quality of life versus thriving business climate. It can be seen in how highly mobile knowledge workers balance economic opportunity and lifestyle considerations in selecting regions to live and work (Florida, 2002).

The dilemma in governance of innovative regions: participative culture versus decisive leadership. It can be seen in the tension between consensus building between a broad spectrum of actors versus taking top-down decisions in governance of innovation systems (Heidenreich and Koschatzky, 2011).

The dilemma of internal dynamics versus cross-border connections: Strong identification with the own regional culture and confidence in traditional innovation strengths versus stimulating innovation by openness for cultural diversity and utilizing a heterogeneity of perspectives. It can be seen in the need to balance 'local buzz' (role of learning processes between actors embedded in a local community in the regional innovation processes) and 'global pipelines' (role of knowledge acquired via global communication channels in the regional innovation process) in innovative regions (Bathelt et al., 2004).

The long term versus short term dilemma: innovations aimed at short term efficiency and profit versus innovation aimed at transformative innovations offering long term solutions for societal and ecological problems. The tension behind this dilemma has even been acknowledged by usually short term oriented venture capitalists: icon venture capitalist John Doerr said in a lecture about climate change and investment (TED Talks series 2007) that he is turning his focus toward innovation in green technologies 'to create a world fit for his daughter to live in' and announced the foundation of a high profile Greentech Innovation Network.

The dilemma of continuity versus change: regional specialization versus diversification. It can be seen in the tension between focus on innovation in dedicated clusters based on past development trajectories versus innovation focused on future potential divergence (Harmaakorpi, 2011).

The strength of an innovation culture is determined by to what extent both sides of the dilemma are connected to each other. The energy is in the tension between the extremes, and the energy that is released by making the connection can act as the driver for change and innovation. Successful regions develop change competence to cope with the dynamic environment, by a continuous process of finding a dynamic balance in each dilemma in a joint effort by various stakeholders (Prud'homme van Reine and Dankbaar, 2011a, b).

The dilemma approach fits in with the regional systems of innovation (RIS) approach, which conceptualizes economic systems as webs of interrelated institutions in a dynamic context in which innovation is the driving force of economic change (Cooke et al., 2004). Tödtling and Trippl (2011) define regional innovation systems as strongly interacting knowledge application/exploitation and knowledge generation diffusion subsystems in a common socio-economic and cultural setting. This implies that the effectiveness of a RIS is influenced by cultural values. A successful RIS requires the development of a distinctive 'regional innovation culture': the pattern of norms, values, attitudes, conventions, perceptions and assumptions that influences the innovation processes of companies in the region. This regional innovation culture is shaped by regional institutional and regulatory structures and in turn shapes how companies interact with each other in the regional innovation system (Asheim and Coenen, 2005). In the dilemma approach, a regional innovation culture is characterized by how the nine regional innovation culture dilemmas are handled.

In the following, the innovation dilemma approach and the systems of innovation approach will be combined into a multidisciplinary approach to understand the impact of regional innovation policies on creating cultures of sustainable innovation.

3 Sustainable innovation

The RIS approach provides a viable theoretical foundation for an approach which includes a wide range of issues relevant for innovation, including sustainability. This is because it sees innovation systems as complex systems in which private and public institutions are linked. Johnson and Lehman (2006) use the term 'sustainable innovation systems': innovation systems in which knowledge is developed and applied that helps to decrease the negative impact of production and consumption

patterns on the environment and on society.

Culture is an essential element of the innovation environment in a sustainable innovation policy (Hautamäki, 2010). The link between sustainability and innovation processes & practices is in creating a culture of sustainable innovation (Vilanova and Dettoni, 2011): a culture that nurtures innovation and sustainability.

However, 'sustainable innovation' is a paradoxical concept. 'Sustainability' is often associated with stability and 'innovation' with renewal. E.g., Hautamäki (2010) argues that sustainable innovation is an essential element of business success as well as social stability in innovation regions. But sustainability can also be understood as a continuous process that requires a dynamic balance between (the emergence of) problems and the capacities to solve these problems. So, sustainable innovation is about a dynamic balance between positive and negative changes in the innovation system. The paradox of sustainable innovation could be described as 'the need to change in order to remain the same'. The dilemma approach to innovation is especially useful to get insight into the development of sustainable innovation regions, because this approach deals with the development of change competence by a continuous process of finding a dynamic balance in a number of fields of tension: tension between preservation of cultural elements in the innovation system that have contributed to success in the past and cultural elements which become visible in capacities and competences to find solutions for new societal and environmental problems. The tension between stability and change can be recognized in the innovation culture dilemmas listed above. Creativity, competition, entrepreneurship, decisiveness, diversity, transformation and diversification are associated with change. Cooperation, trust, process orientation, consensus, cultural identification, efficiency and specialization in traditional regional strengths are associated with stability. Sustainable innovation requires a dynamic balance between stability and change and the innovation culture dilemmas show that change and stability are indeed not mutually exclusive. The stability of cooperation and trust can form the basis for the willingness to change that fits with open innovation (Chesbrough et al., 2006). The stability offered by high quality of life can be the basis for pioneering activities of creative entrepreneurs (Florida, 2000). The stability of a consensus culture can results in fast implementation of change after all stakeholders had the opportunity to contribute (Heidenreich and Koschatzky, 2011). This suggests that innovation policies aimed at developing sustainable innovation cultures can be assessed by how they address the innovation culture dilemmas.

4 Research

Many innovation regions in the world aim to transform into a 'sustainable innovation region'. In Silicon Valley, the Sustainable Silicon Valley (SSV) initiative is a case in point (SSV 2013). SSV is a collaboration of regional government agencies, businesses and community organizations with the mission to guide the Silicon Valley community to a more sustainable future: an economically vibrant, environmentally healthy and socially equitable Silicon Valley. In The Netherlands, the region Southeast Netherlands (SEN), also known as the 'Brainport-region' (Brainport, 2011) has the ambition to develop into a sustainable innovation region. In the following the

innovation culture dilemmas will be used to assess how the challenges in the development of a sustainable innovation culture in these regions are addressed.

The assessment of how innovation dilemmas are handled in Silicon Valley in this article is based on an analysis of the extensive literature about this region (e.g. Kenney, 2000; Lee et al., 2000; Saxenian, 1994, 1999 and 2000; Saxenian and Hsu, 2001; Wang and Horowitt, 2012). The assessment of how innovation dilemmas are handled in the region Southeast Netherlands (SEN) is based on the results of empirical research in the region which will be described in the following.

SEN consists of the Southeast of the province of Brabant and the province of Limburg in The Netherlands. Its most important innovation centres are Eindhoven (with the open innovation campus HTCE, the University of Technology Eindhoven, and innovative high tech companies such as Philips and ASML), South-Limburg (with the Chemelot open innovation campus, the University of Maastricht and innovative companies such as life sciences/performance materials company DSM) and Helmond (with the Automotive open innovation campus). Characteristic for the region is the presence of a number of clusters in which innovative companies collaborate with knowledge institutes: high tech systems, performance materials, life sciences, energy, design, food technology, ICT and automotive. Environment, climate, clean energy, mobility and health are considered to be the most important sustainability challenges in the region. The results reported in this article build further on research conducted in the SEN-region in the period 2008-2010 within the scope of the CURE project (Corporate Culture and Regional Embeddedness). The main research topics in this project were innovation and sustainability. Results of this project on the topic of innovation have been reported previously (Prud'homme van Reine and Dankbaar, 2011a), however, the results on the topic of sustainability have not been reported in detail so far. The results on sustainable innovation in the SEN region were re-analysed and supplemented with recent research. The research in the period 2008-2010 consisted of 49 semi-structured in-depth interviews with companies and organizations involved in the regional innovation system, such as regional governments, chambers of commerce, regional development agencies, knowledge institutes and the management of open innovation campuses; participant observation at ten conferences and seminars in the region; and document analysis (studying documents on the regional innovation system and culture). Supplementary research was conducted in the period September 2011-February 2013 and consisted of twenty interviews with managers working at innovative companies in the region, including expats from Asia, East-, South-, West and North-Europa, South-America and North-America; participant observation at four conferences and seminars (presentation of the 'Brainport 2020' plan for the regional innovation system, seminar on regional innovation policy at the open innovation campus Chemelot, an international innovation workshop in Eindhoven and an 'open chemical innovation' workshop in the region); and updating the document analysis.

The research outcomes were analyzed by categorizing the interaction between both sides of each innovation dilemma by distinguishing the following patterns (Prud'homme van Reine and Dankbaar, 2011a): 'productive interaction' between both sides of the dilemma (synergy); 'one-sided emphasis' (neglecting the other side of the dilemma), 'disconnect' (no connection between the two sides of the dilemma) and 'negative interaction'.

5 Sustainable innovation culture: results per dilemma

5.1 Technology/content driven RIS versus RIS driven by users and market needs

This is the equivalent at the regional level of the well-known 'technology push' – 'market pull' dilemma. In a technology/content driven RIS, ideas for new products and services come mainly from internally driven engineers and researchers, often resulting in products and services with top technology, but little attention for design and low consumer friendliness. In RIS driven by users and market needs, ideas are generated by responsiveness to customer needs, and even mobilizing customer needs.

In a sustainable innovation culture, environmental and societal challenges are translated into innovative concepts such as ecological and health products and services which anticipate market needs. Regional innovation policy can stimulate this by making the region act as a 'launching customer' for products and services that offer solutions for sustainability issues.

Silicon Valley

In Silicon Valley, the role of 'technopreneurs' connecting technological to innovative business opportunities is crucial in developing a dynamic balance on this dilemma. A technopreneur is an entrepreneur who combines being technology savvy, creative, innovative and risk-taking with the ability to recognize customer needs. A technopreneur does not follow market trends but gathers insights into needs and desires of customers and uses technological expertise to set new trends. Apple co-founder Steve Jobs is the classic example of a Silicon Valley technopreneur. More recent examples are the founders of Instagram who emphasize that identifying the problems that people have with mobile photos was the hardest part for their successful venture - building the minimum viable product, getting vital customer feedback, building simple solutions instead of complicated solutions and bringing that simple solution to the masses came next. Technopreneurship is not limited to entrepreneurial firms in high technology areas. The concept can also be used for entrepreneurial firms in other sectors. Perhaps it is better to use the term 'expert entrepreneur': an entrepreneur who is able to bridge the 'content side of innovation' with the 'meaning side of innovation'. Developing an innovation culture requires stimulating expert entrepreneurship by providing a framework so that 'customer innovators' and 'lead users' can participate in the innovation process. In Silicon Valley, Google recently built the 'Google Experience Center', 'to share visionary ideas, and explore new ways of working' with its clients and business partners.

The innovation culture in Silicon Valley has benefited from the role of big contracting authorities as 'launching customer', especially defense contracts demanding innovative technology which could be transferred to commercial applications. Currently, similar productive interaction in the region between inventors, entrepreneurs, investors and the public sector results in the development and deployment of innovative solutions in the clean technology and renewable energy industry. Entrepreneurship is stimulated via the 'Clean Tech Entrepreneurship' course at Stanford University. At the demand side, the state of California takes a leadership role in enacting polices to create an early market for technology related to energy

efficiency, clean air and water and renewable energy. Examples are a policy plan to transform the Bay Area around San Francisco into the Electric Vehicle Capital of the U.S. and public-private cooperation in the East Bay Cleantech Corridor.

SEN region

In the SEN region, the emphasis on this dilemma is on technological potential. An example is anchor company Philips, known for being technology oriented and product development driven with engineers dedicated to complexity. Philips appointed an outsider, Italian Andrea Ragnetti, as Chief Marketing officer in order to become more customer oriented. One of his first actions was to ask Philips managers to test their company's products at home in the weekend. Many returned to the office frustrated and admitted that the innovative products were too complicated for users. Ragnetti then introduced the slogan 'sense and simplicity' in an effort to direct innovation towards applications and solutions that are simple to use and make sense. However, when Ragnetti was forced to leave Philips in 2010, he was still a controversial figure at the company and Philips was still known as predominantly 'technology push' oriented.

Another example in SEN is the 'Phileas', an innovative and environmental friendly public transport system developed by the company APTS with regional industry leader VDL as most important shareholder. The Eindhoven city region acted as 'launching customer' of the Phileas, partly in order to strengthen the innovative image of the region. However, eventually the project reinforced the image that the region is too much technology focused. The Phileas is an electrically driven road vehicle with a large number of innovations in its original design, such as an automatic guidance system. The first prototype of the Phileas was a brilliant design but it faced many technical problems. Even the designers acknowledge that the design was perhaps too futuristic and incorporated too many new features in one product. In the next generation a number of innovations were eliminated so that the Phileas is now operational, but technically the system hardly differentiates itself from a normal city bus.

A lot has been done in the region to develop a more customer oriented culture, such as attention for design, but the regional innovation culture is still predominantly technology oriented, also in the field of sustainability.

5.2 RIS characterized by open innovation in cooperative trust-based relationships versus RIS characterized by closed innovation in competitive relationships

In a culture characterized by cooperation and trust, knowledge sharing in networks facilitates open innovation. However, too much networking may lead to regional 'lock-in'. Competition is associated with competitive rivalry, resulting in motivation for innovation. However, lack of trust may result in lack of knowledge sharing, hampering the innovation process. In a sustainable innovation culture, companies and suppliers cooperate informally with the goal to have joint success with innovative solutions for societal problems, but a sustainable innovation culture must also be competitive to survive competition with other regions.

Silicon Valley

Silicon Valley has been described as a flourishing regional innovation system by the combination of very competitive circumstances and co-operative attitudes (Saxenian 1994). Saxenian describes how Silicon Valley firms were successful by competing intensely, while networking and collaborating in informal and formal ways with one another. Leading innovative companies in the region such as HP and Intel are known for being very competitive but also open in partnerships to ensure that their innovations diffuse rapidly throughout the region and the industry.

This 'co-opetition' attitude is maintained in sustainable innovation as well. Many sustainability start-ups in Silicon Valley have only a small market share or only sell licences on research patents, but because of their competitiveness, larger companies feel compelled to cooperate. E.g., Silicon Valley electric-vehicle start-up Tesla has affected the automotive industry despite its small market share, because large car makers feel obliged to invest in electric-vehicle development and partner with a high profile company such as Tesla. Another example is how clean tech companies cooperate in lobbying for effective sustainability policies, in developing green technologies to accelerate sustainable innovation and in establishing the standards required to ensure that new technologies such as charging infrastructure for electric cars can be rolled out. An example of co-opetition in Silicon Valley is in the field of 'smart grids', the combination of innovative transmission equipment, innovative meters, and innovative software applications that all interact with each other to increase energy network efficiency. AutoGrid Systems, a Silicon Valley startup in 'big data' analytics for the electricity and energy industry, and Silver Spring Networks, a Silicon Valley based networking platform and solutions provider for smart grids, are competitors but also have a strategic partnership to jointly develop an innovative energy-saving demand optimizer solution for utilities, grid operators, service providers, and large power consumers.

Summarizing, there is positive interaction on this dilemma in sustainable innovation, because the need to work together to address sustainability challenges goes together with the need for urgency and innovation brought about by competition.

SEN

The term 'friendly' is often used to describe the culture of the SEN region: it is relationship oriented, companies and suppliers share knowledge in formal and informal networks and innovation leaders are easily approachable. Regional policies aim to bring companies and other regional actors together by providing networking opportunities, creating network organizations, coordinating projects to stimulate co-operation and knowledge sharing and by creating places for competing companies to co-operate as partners in innovation: open innovation institutes which are often structured as public-private partnerships. The atmosphere on the open innovation campuses in the region fits with the tradition of networking and sharing. However, there is also criticism in the region itself: 'sometimes there is too much networking going on'. This means there is a risk of regional 'lock-in' and lack of innovation. The need for more competitive attitudes is felt in the region, but leads to a certain level of distrust: 'the old model of cooperation was based on trust, but now we have to sign extensive contracts'. This problem shows up especially in the life sciences sector, important for sustainable innovation. The background is a cultural difference between

how intellectual property is dealt with in different sectors. In the electronic industry, until recently dominant in the region, it was customary to exchange patents. In the life sciences industry, companies strive to get exclusive intellectual property rights, either by closed innovation or by obtaining patents via acquisitions. The region tries to solve this 'trust-issue' by finding creative ways to share Intellectual Property Rights and by encouraging knowledge institutes to take the lead in open innovation projects.

Summarizing: in the field of sustainable innovation, the regional innovation culture in the SEN region is dominantly cooperation and trust oriented.

5.3 The dilemma between creativity and consistency in regional innovation systems

Room for creativity is necessary for entrepreneurs, designers, researchers etc. to generate inventive ideas for products and services. A culture of innovation requires entrepreneurial spirit, artistic freedom, tolerance for creative, committed and often eccentric people – or, according to 3M, the first company which claimed to have a culture of innovation, 'tolerance for tinkerers'. Consistency is necessary to ensure the widespread use of these inventive ideas and products, e.g. engineering standards and innovation systems. A sustainable innovation culture needs the capability for 'disciplined creativity' – the will to continuously improve new concepts.

The debate about what type of companies contributes the most to innovation – big, resourceful companies or small, creative companies – dates back to the writings of Schumpeter (McCraw, 2007). The debate was recently revived by the claim that IBM's innovation processes make that 'IBM is better in creating a sustainable innovation culture than Apple has ever been or will be' (Fidelman, 2012). However, according to the dilemma model a sustainable innovation culture is based on connecting the strengths of creativity and discipline in the innovation process.

Silicon Valley

In Silicon Valley, the connection between the strengths of creativity and discipline can be seen in the interaction between small entrepreneurial companies and more process oriented large companies in the region, but also within companies. E.g. Intel is known as being open *and* authoritarian, Google is known for combining 'relentlessly experimenting' in a 'fun' work environment with discipline in support processes. Icon of creativity and innovation Apple benefited in its early days from the interaction with the Xerox research centre in Silicon Valley and is now known for combining creativity and room for imagination with disciplined project management. Currently, Xerox runs an 'Artists in Residence' program at its Silicon Valley based research centre based on the idea that by putting creative people together (artists with researchers), innovation will naturally emerge.

The culture of disciplined creativity is maintained in sustainable innovation as well. Silicon Valley based founder of the biotech industry Genentech is a case in point. It nurtures a culture that values innovation and has as its mission addressing significant unmet medical needs and making medicines that matter. It was known for its 'independent and free-wheeling culture of innovation' throughout its twenty years of partnership with the large pharmaceutical firm Roche, and maintains this culture after a full takeover by Roche in 2009.

SEN

In the SEN region, the city of Eindhoven calls itself a 'creative biotope'. In reality the regional innovation culture is still dominated by large companies such as Philips and DSM. The risk of dominance of big companies is that they tend to specify innovation processes in so much detail, that creativity is stifled and a culture of avoiding risks develops. In the field of sustainable innovation, this has happened in the lighting industry. Philips Lighting was as a world leader in lighting also leading in innovation in compact, energy saving fluorescent lamps. For these type of lamps, a relatively slow innovation trajectory is acceptable because large investments are necessary for newcomers to gain a market position. When LED lighting came up, the pace of innovation in the industry increased rapidly and creative American and Asian companies could catch up with Philips Lighting, because speed was not the strength of the company and the region. Philips Lighting had to acquire smaller companies in LED-lighting in order to re-establish its leading position. In parallel, it started a culture change program under the name 'accelerate', with the goal to reduce complexity in the innovation process. Interestingly, one of the companies acquired by Philips was Silicon Valley based Lumileds Lighting, confirming the need to combine strengths of small and large companies in a sustainable innovation culture.

In the life sciences industry, dominance of large companies plays a role as well. Interviewees from smaller and medium sized companies (SMEs) report tension between dominant big players (Philips Healthcare, DSM) and SMEs notably in the field of patents. Big companies reportedly use their dominant position to claim intellectual property. A number of SMEs perceives that public-private partnerships in innovation programmes supports mainly big companies, which get access to intellectual property from the public domain but protect their own intellectual property.

The presence of big players with financial resources offers opportunities for small companies as well: participation in sustainable innovation projects that require large investments and cooperation with big companies in commercialization of sustainable innovations. However, in the current regional innovation culture, the dominance of large process oriented companies leads to one-sided emphasis on the consistency side of the dilemma.

5.4 RIS focused on fundamental research versus RIS focused on application oriented R&D

The term 'knowledge paradox' refers to regions where this dilemma has not been resolved and high investment in good quality fundamental research results in insufficient economic returns, e.g. in The Netherlands (Boekema et al., 2000). In a sustainable innovation culture, investments in fundamental research are seamlessly connected to realizing innovative products and services that offer solutions for societal issues. The role of knowledge institutes is to help in building 'absorptive capacity': the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends, which is critical to its innovative capabilities (Cohen and Levinthal, 1990).

Silicon Valley

The knowledge paradox doesn't apply to Silicon Valley. Especially Stanford University and its Research Park in Palo Alto played a key role in the emergence and growth of Silicon Valley as an innovation region by fostering creativity and entrepreneurship. Stanford graduates have founded innovative companies in the region such as Hewlett-Packard, Cisco, SUN, Yahoo and Google. The Stanford Technology Ventures Program (STVP) is dedicated to high-technology entrepreneurship education and research that provides new insights for students, academics and business leaders. It gives students the opportunity to get in touch with entrepreneurs, venture capitalists and consulting companies in the sustainability sector as well. In the field of sustainable innovation, Stanford focuses on cleantech and renewable-energy, in solar technology and low emission technology but also in innovation in the economics of the energy system, e.g. how to cost-effectively scale up solar power and other forms of renewable energy. Stanford graduates have contributed to sustainable innovation in the region by founding companies such as electric car company Tesla Motors and solar energy company SunPower. Examples of Stanford spin-offs are Nanostellar, a company developing materials for automotive emissions control, and Mango Materials, a company in innovative technology to produce biodegradable plastic from waste biogas.

In the area of social innovation, Stanford has also contributed to the foundation of innovative non-profit organizations in sustainability. An example is Kiva, co-founded by two Stanford graduates. Kiva is an innovative system that makes it possible for people around the world to loan small amounts of money to entrepreneurs around the world struggling to found often tiny businesses e.g. in clean energy and organic farming.

The positive interaction on this dilemma in Silicon Valley is apparent in how entrepreneurial university faculty members and students combine knowledge, intellectual passion and curiosity with awareness of commercial and societal implications of their research, thereby acting as a bridge between university and business.

SEN

In the SEN region, the Dutch innovation paradox has been acknowledged and addressed by establishing research institutes and programs structured as public-private partnerships to bridge the gap between education, fundamental research, innovation and entrepreneurship. Top university research groups cooperate with companies to make the connection between fundamental research and development of products and services. These institutes and programmes are modelled after the open innovation concept and are largely based on the open innovation campuses in the region. Examples are CTMM (Centre for Translational Molecular Medicine) and BMM (BioMedical Materials programme): research programmes in the field of life sciences and biomedical materials in which academic hospitals are involved and therefore very relevant for sustainable innovation. The focus in CTMM and BMM projects is, however, on fundamental research. Product development and commercialization is out of the scope of these programmes. SMEs think more in terms of economic profit on the short term, and are therefore reluctant to participate.

A second approach to address the knowledge paradox is valorization of investments

in fundamental research by stimulating academic entrepreneurship. However, according to interviewees at the business side, the emphasis on valorization makes academic knowledge actually less accessible for companies because university spin-offs protect their unique knowledge and intellectual property. Moreover, universities are more distant from the market which makes it difficult to file good patents. The costs of scaling up and commercialization are often underestimated. In the SEN regional innovation culture, the knowledge paradox has not been completely resolved, so that a 'disconnect' between both sides of the dilemma is still present.

5.5 RIS characterized by high quality of life versus RIS characterized by thriving business climate

This dilemma describes the tension between 'soft' quality of life and 'hard' economic factors. On the one hand, innovation is fostered by attracting the 'creative class' by focusing on soft issues: an attractive natural and urban living environment, vibrant cultural scene, good educational climate. However, a pleasant, friendly and relaxed region may also end up as a retirement haven. Focus on hard economic factors is necessary as well: opportunities to perform and achieve in business, such as availability of venture capital and infrastructure. But if a thriving business climate goes at the expense of quality of life, businesses may start seeking improved quality of life elsewhere for their innovation activities. In a sustainable innovation culture, sustainability challenges lead to commitment and job satisfaction because work serves a valuable purpose, which in turn helps in attracting and retaining talented people.

Silicon Valley

Silicon Valley's innovation culture benefits from the balance between economic opportunities and lifestyle considerations (Florida, 2002): an attractive green, safe environment; the inspirational urban environment and cultural facilities of nearby San Francisco; inspiring office architecture and office space e.g. Googleplex, in combination with a result oriented and achievement oriented culture and the presence of major venture capitalist companies resulting in a thriving business climate.

The emerging sustainable innovation sector contributes to positive interaction on this dilemma it adds to the attractiveness of the region because entrepreneurs and workers in sustainability sectors find additional motivation in working on tangible ('green') projects that are seen as worth your while to work for. Moreover, due to the attractiveness of the region for venture capital, a company has emerged that serves as icon of the sustainability industry: electric car company Tesla Motors.

SEN

In the SEN region, regional policies focus on the 'soft' side of this dilemma, enabling an attractive living environment: improve image/brand as innovative region; develop an attractive urban, green and safe environment and develop attractive open innovation campuses with iconic buildings which serve as symbolic capital for new ways of working and sustainable development. This emphasis can be explained partly by the scarcity of business talent: 'there are more ideas for innovative companies than entrepreneurial talent to take up these ideas and turn them into a success'. Another explanation is that the amount of venture capital available in the region is much less than in Silicon Valley. Several initiatives in the region which seemed to have the

potential to develop into a regional icon for sustainable innovation failed due to lack of capital or lack of a solid business case, e.g. Solland Solar (solar cells), Duracar (electric vehicles) and the Silicon Mine (raw material for solar cell manufacturing).

Philips and DSM try in their sustainability strategy to compensate the lack of venture capital by creating their own venture capital divisions, in order to bring in external knowledge and to find external paths to bring own technology to the market. For instance, Philips participates in a venture capital fund targeting innovative companies in health care and invests in the Philips Healthcare Incubator. DSM invests via its venture capital division in innovative companies in life sciences, biodegradable materials and sustainable energy.

The regional innovation policy is aimed at strengthening the 'hard' side of the dilemma by stimulating education in entrepreneurship, stimulating creative entrepreneurship and stimulating interaction between technologists and venture capitalists e.g. by organizing seminars with success stories of venture capitalists on the open innovation campuses.

However, in the current innovation culture, the 'soft' and 'hard' sides are still insufficiently connected.

5.6 The dilemma in governance of RIS: participative versus decisive leadership

Decisiveness in innovation policy leads to clear focus, but some stakeholders may feel excluded. Bottom-up involvement including public participation runs the risk of supporting too many initiatives in order to keep everybody satisfied. Innovation policy is about the orchestration of diverse, conflicting and competing interests (Cooke and Schwartz 2011) and requires a combination of decisive policy making and bottom up consultation and participation in program design. In a sustainable innovation culture, a clear vision from the region on sustainability serves as inspiration for bottom-up initiatives by entrepreneurs to take up sustainability issues.

Silicon Valley

The image of Silicon Valley is that of an innovative region based on bottom-up initiatives, but the influence of government policies on the regional innovation system in Silicon Valley is more important than often suggested. Especially high levels of spending by the Defense Advanced Research Projects Agency acted as a catalyst for the formation of high-technology firms in the region. Even Google originated from government-university collaboration, in a data mining program at Stanford University. The first Apple computer came into existence after the development of new processors in the semiconductor industry, facilitated by large-scale government procurement. In 1993, Joint Venture Silicon Valley JVSV was established, an organization bringing together leaders from business, including venture capital firms, government, academia, labour and the broader community, with the goal to provide analysis and action on issues affecting the region's economy and quality of life and work toward innovative solutions. In the field of sustainable innovation, the Advanced Research Projects Agency-Energy (ARPA-E) is inspired by the Defense Advanced Research Projects Agency. ARPA-E funds innovative and promising projects that have the potential to revolutionize energy technology for the next

generation and supports several renewable energy projects in Silicon Valley.

Still, in the current regional innovation culture the emphasis is more on bottom-up initiatives than on top-down guidance.

SEN

The SEN region is proud on its 'triple helix' model of intensive cooperation between regional (semi) government agencies, business and knowledge institutes, However, the triple helix model has disadvantages as well. Cooperation in the triple helix can easily lead to a conflict avoiding consensus culture. A sustainable innovation culture requires being able to say 'no' to initiatives because of the limitations in innovative capacity. Especially expatriates working in the region express the view that too many initiatives are started in the region, while there is already a lack of resources for existing innovation projects. This leads to fragmentation of initiatives. E.g., the sub-region Limburg developed separate plans for innovative clusters 'Energy Hills' (solar energy cluster) and 'Health Valley' (health care) which turned out to be too ambitious.

SEN included sustainability in its vision for 2020 as a framework condition (Brainport, 2011), but within the region the view is expressed that the region should be much more decisive in making its mark in sustainable innovation (KPMG Advisory 2012). Summarizing, in the current regional innovation culture there is a strong emphasis on the participative side of the dilemma.

5.7 Strong identification with the regional culture versus leveraging cultural diversity for innovation

Strong linkages and knowledge transfer at the local level results in the use of traditional strengths in innovation but limited connection to distant knowledge sources. Global connections and openness to cultural diversity allow for tapping into a wider knowledge base for innovation but may go at the expense of using traditional strengths in innovation. In a sustainable innovation culture, 'cross-border' connections are used to integrate diverse knowledge in the regional innovation system. Ideas in the field of sustainable innovation developed by immigrants or the foreign subsidiaries of regional companies are embedded in the innovation system and vice versa. The term 'reverse innovation' refers to the migration of innovations generated in emerging markets, e.g. Asia, to the world market, thereby translating the cultural influence of a region into products and impact on the world economy. Sustainable innovation benefits from 'brain circulation'' (Saxenian, 1999, 2000) as a global channel for knowledge transfer (Hautamaki, 2010).

Silicon Valley

Silicon Valley has benefited from cultural diversity because immigrant entrepreneurs have contributed to the success of Silicon Valley as an innovation region and often maintained connections to Silicon Valley after migrating back to their country of origin (Saxenian and Hsu, 2001). 'Immigrants' are embedded in the regional innovation system as entrepreneurs, knowledge workers, managers, advisers and investors.

In the field of sustainable innovation, Silicon Valley benefits from the connection between identification with the regional culture and leveraging cultural diversity as

well. The originally Indian co-founder of Sun Microsystems, Vinod Khosla, serves as an example. After his career at Sun, Khosla became venture capitalist at the firm Kleiner Perkins and now has his own venture capital firm Khosla Ventures which focuses on investments in 'clean technology' and is also active in social entrepreneurship and sustainable energy.

SEN

The SEN region is historically a peripheral region in The Netherlands and as a consequence still very much focused on its traditional regional identity in comparison with other innovation regions. Expatriates working in the region perceive SEN as insufficiently open for ideas from other cultures: 'there is still a lack of cosmopolitan atmosphere in the region'. However, the further internationalization process and establishing cross-border connections proceeds rapidly. International oriented companies and regional education institutes attract global talent to the region to stimulate the international atmosphere. Moreover, leading company Philips has embraced the 'reverse innovation' concept for a number of sustainable innovations. For example, Philips introduced worldwide health care products originally developed in India for the Indian market. Driving forces for sustainable innovation in this case are deployment of equipment at large distances of regular hospitals and affordability. Summarizing, the regional innovation culture in SEN shows limited productive interaction between identification with the own culture and openness for cultural diversity.

5.8 Innovations aimed at long term solutions for societal and ecological problems versus innovations aimed at short term economic profit

This dilemma is related to the shareholder – stakeholder dilemma: emphasis on short term shareholder interest versus emphasis on long term interest of stakeholders including society at large. In a sustainable innovation culture, innovations create long term value for society and the environment *through* generating short-term economic returns. A sustainable innovation culture requires availability of short term finance and long term finance and a sustainable financial infrastructure: a financial sector that stimulates, facilitates and supports the transition of the economic system to a sustainable, circular organized economy which serves mankind without depleting its living environment and resources.

Silicon Valley

Silicon Valley is renowned for venture capital funding aimed at maximizing short-term investment returns, which has promoted the emergence of the 'dotcom sector'. However, initiatives such as 'Sustainable Silicon Valley' have made that the balance of funding has shifted and the region's clean technology and renewable energy industry is rapidly attracting more funding. Silicon Valley's 'cleantech sector', sometimes dubbed Silicon Valley's 'new field of dreams', includes companies in biofuels (e.g. Solazyme, Codexis), electric vehicles (Tesla Motors), lighting (e.g. Lunera Lighting), solar (e.g. Solar City and SunPower), energy storage (e.g. Bloom Energy, a company that creates fuel-cell boxes that can power big data centres) and smart grid (e.g. Silver Spring Networks). Silicon Valley's venture capitalists are increasingly adding 'clean' or 'green' technology companies to their investment

portfolios, but investments in many failed to deliver the returns the investors expected. The question is, if they are willing to make even larger investments in disruptive innovations needed to solve environmental challenges.

Thanks to Silicon Valley's reputation in transforming innovations to big businesses it is seen as having the potential to take 'greentech' out of the domain of 'lifestyle' and subsidized projects. The following comments of an observer of Silicon Valley's sustainable innovation culture suggests that there is at least some productive interaction on this dilemma: 'We underestimate the importance of Silicon Valley's entrance into energy matters, but the reason isn't their technological knowledge or funding – it's cultural. Politically, Silicon Valley venture capitalists – as an idea, as paragons of American innovation – are potent, far more potent than more alternative lifestyle-linked green technologists' (Johnson, 2010).

SEN

The SEN region supports and stimulates sustainability initiatives and has embraced the 'Cradle to Cradle' concept of sustainable design and innovation (McDonough and Braungart 2002). However, within the region there is some skepticism towards 'Cradle to Cradle', because the economic value is not always clear. The pioneer of Cradle to Cradle in the region is the company DSM. DSM's 'Climate induced innovation' initiative has realized innovations in renewable energy, biofuels, metal replacing composites that make means of transport lighter and energy-saving, and lacquers with environmental friendly solvents.

The regional innovation culture in SEN shows limited productive interaction on this dilemma.

5.9 The dilemma of continuity versus change of the regional innovation system: regional specialization versus regional diversification

Specialization has the advantage of regional focus in innovation and exploitation of traditional regional clusters. However, too much specialization may impede radical innovations. Diversification means opportunities for cross-fertilization, however, a region cannot be world leader in everything. In a sustainable innovation culture, sustainable challenges act as a change agent for the innovation system. The idea of 'diversified specialization' is developing regional innovation platforms which connect past trajectories to future innovation potential aimed at solving societal and environmental needs. 'Regional innovation platforms' are future oriented and based on cross-fertilization between existing specialized clusters by making unorthodox combinations. Potential platforms are identified by exploring opportunities to create synergy at the interfaces of existing clusters.

Silicon Valley

Silicon Valley is mainly known for its high tech electronics cluster but in fact has multiple crosscutting and hybridizing innovation clusters at various stages of development. Building upon microwave technology in the 1950s, it developed its semi-conductor and electronics platform further to internet technology and a social media platform. A venture capital industry grew from successful development of the semiconductor and electronics platform. In turn, the venture capital industry was instrumental in creating a biotechnology cluster, building on academic research and

academic entrepreneurship at Stanford and the University of California, where the potential of the 'double helix' discovery was recognized, resulting in the invention of recombinant DNA, the key to realize the practical potential of DNA. This led to the foundation of Genentech, the forerunner of the regional biotech cluster.

The newly emerging sustainability platform in Silicon Valley is based on cross-fertilization between biotech, electronics, semiconductor, internet and social media clusters, again supported by the venture capital industry in the region. Summarizing, there is productive interaction on this dilemma in sustainable innovation in the Silicon Valley region.

SEN

In the SEN region, a number of sustainable innovation platforms are being developed, all based on cross-fertilization between existing clusters:

- Smart mobility platform: Interface of High Tech Systems, Automotive, ICT and Design clusters
- Medical Technology platform: Interface of Life Sciences, High Tech Systems, Performance Materials and Design clusters
- Food for Life platform: Interface of Food Technology and Life Sciences clusters
- Smart grids platform: Interface of Energy, ICT and High Tech Systems clusters.

On this dilemma, there is productive interaction between continuity and change in the sustainable innovation culture in the SEN region.

6 Conclusions

The nine innovation culture dilemmas can serve as a 'checklist' to prevent fragmentation of initiatives in regional innovation policies. Isolated initiatives such as creating an attractive cultural environment for the 'creative class' or attempts to create a sustainable innovation culture out of nothing have little chance of succeeding – the development of a sustainable innovation culture requires a joint effort in a wide range of issues by government, knowledge institutes, companies and financiers, and balancing top down policies with participative processes.

The focus in RIS theory and regional innovation policies has been rather one-sided with emphasis on continuity rather than change. Too much focus on continuity rather than change poses the risk of regional 'lock-in'. Examples are one-sided emphasis on proximity, collaboration and trust (IRE Working Group 2008: 15 - 'the functionality of a regional innovation system is essentially a matter of cooperation culture'), on the existing regional knowledge basis (Asheim and Coenen, 2005) and on stakeholder participation (Heidenreich and Koschatzky, 2011). More attention for dynamic elements in regional innovation systems such as connectivity, competition, achievement, diversity of ideas and change is necessary to increase the capabilities in RIS to find solutions for societal and environmental problems. Regional Innovation Systems should be seen as a dynamic environment in which knowledge, creativity and entrepreneurship are transferred into sustainable innovations.

The nine innovation culture dilemmas can be used for benchmarking Regional Innovation Systems in terms of how the dilemmas are handled. Copying 'success formulas' from other regions is impossible – the dynamic balance depends on history and culture of the region. However, an analysis of a specific region will reveal strength and weaknesses in innovation policies aimed at developing a sustainable innovation system. Competitiveness of a regional innovation system is determined by the weakest link. The preferred approach in regional innovation policies is not 'either – or' (focus on one of the extremes of the dilemma); not 'and- and' (addressing both extremes but not necessarily connecting them) but 'through-through' – connecting both sides of the dilemma in a continuous process of finding a dynamic balance in a joint approach by all stakeholders – there are no permanent solutions.

The analysis of how innovation culture dilemmas are handled in the Silicon Valley region shows positive interaction on most dilemmas, with the exception of dilemma 6 (one-sided emphasis on bottom-up initiatives and not enough attention for top-down guidance) and dilemma 8 (limited productive interaction: emphasis still too much on short term orientation side of the dilemma).

The analysis of the SEN region leads to the following results in terms of categories of how the innovation culture dilemmas are handled:

- 'One-sided emphasis' on one side of the dilemma while neglecting the other side. This is the case for dilemma 1 (dominant technology orientation) and dilemma 3 (dominant process orientation). In both cases, the explanation is in the history of the region: the dominant presence of large technology oriented companies such as Philips, DSM and DAF and a large university of technology. One-sided emphasis also holds in the case of dilemma 2 (emphasis on cooperation and trust, related to the traditional informal way of doing business in the region) and dilemma 6 (emphasis on participative culture at the expense of decisiveness), in both cases related to the abovementioned emphasis in regional innovation literature on cooperation, trust and participation. Developing a sustainable innovation culture with productive interaction on these dilemmas will require more attention for elements such as demand driven business models, speed, competition and decisiveness.
- 'Disconnect'. This is the case for dilemma 5 where actions in enhancing quality of living environment and in enhancing the business climate are not yet sufficiently connected. Although there are actions aimed at developing an attractive living environment and actions to stimulate entrepreneurship, there is perhaps too much involvement of the public sector in the activities of starting entrepreneurs and not enough acceptance of the fact that failures are part of a sustainable innovation culture as well.
- 'Negative interaction'. This is up to a certain point the case for dilemma 4. The Dutch 'knowledge paradox' is acknowledged in the region, but the current emphasis on knowledge valorization by universities makes academic knowledge in the perception of some SMEs actually less accessible. Perhaps universities are positioned too much as 'drivers' of the innovation system in publications about sustainable innovation.
- 'Productive interaction'. This is clearest for dilemma 9 which shows a dynamic balance between continuity (focus on regional specialization) and

change (regional diversification). The explanation for this is that the region has developed 'change competence' by the need to handle previous crisis situations such as the simultaneous problems at leading companies in the region Philips and DAF around 1990 and the experience of another leading company, DSM, with large transformations (from state mining company to privatized petrochemical company to life sciences company). As a result, the current economic crisis is seen as an opportunity to renew the innovation system and direct it towards sustainability. For dilemma 7, there is limited productive interaction. The history of the region as a peripheral region in The Netherlands results in a strong identification with the own regional culture, however, due to the presence of strongly international oriented companies in the region the openness for cultural diversity increases rapidly. For dilemma 8, there is limited productive interaction as well. Innovation aimed at long term solutions for sustainability issues ('people' and 'planet') has been taken on by companies in the region, but is still too much associated with idealism and subsidies instead of 'profit'.

Finally, it can be concluded that evaluating how innovation dilemma are handled provides a viable approach to exploring the dynamics of creating sustainable cultures of innovation. However, there are some limitations to this study due to the case study approach focusing on comparison of two industrial regions, one dominated by a few large companies and the other with a vibrant mix of large and small companies. Further research is necessary to assess the generalizability of the approach. Future research may focus on comparing regions with similar industrial sectors, on including regions in less developed countries, and on including regions where services or creative industries are dominant.

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Chinese firms' outward FDI entry mode choice: The role of ownership and network

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Abstract. What determines the Chinese firms' outward foreign direct investment (FDI) entry mode choice, and do they behave differently from the firms from developed countries? To answer this question, this exploratory study firstly summarizes the attributes of the FDI entry modes, including greenfield investment, acquisition, and joint venture. Further based on the different attributes of these three modes, we analyze how Chinese firms choose the entry mode from the role the ownership and network perspectives, which are the important characteristics of Chinese firms.

Keywords. entry mode, ownership, network

1 Introduction

Internationalization has been widely considered as the dominant tendency of our time (Mathews, 2006), and entry mode choice as one of the most critical decisions during the international expansion, one of the key strategic decisions during the firms' development (Brouthers and Brouthers, 2001; Luo, 2001). There are theories widely applied to analyze the entry mode choice, including the transaction cost theory, resource based view, and institution based view, which have been considered as the tripod of international business. However, among these studies the empirical study results are still not consistent. For example, there is no clear consensus regarding the effect of cultural distance on entry mode choice (Brouthers and Brouthers, 2001; Tihanyi et al., 2005). Besides, more and more firms from developing countries have begun to invest in the international markets. Not like firms from developed countries gradually investing internationally, firms from developing countries prefer to choose more aggressively strategy – high risk (commitment), high level of control, and high speed. These 'tripod' theories developed within developed countries background are found difficult to explain this new trend of internationalization.

Facing the above research gap, this study will introduce the agent theory and network perspective into analyzing the entry mode choice of Chinese firms' outward FDI. Coviello and Martin (1999) contended the network relationship influence initial market entry and mode of entry, and FDI is viewed as an effort by investors to forge linkages with foreign networks by establishing a presence in the foreign country under the network perspective (Chen and Chen, 1998). But to date there have been

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few researches investigating the specific implications to the FDI entry mode choice from the network perspective. Researches on corporate governance within the context of firm internationalization are relatively sparse too (Tihanyi et al., 2005), and even the current limited researches are mainly about the interaction between internationalization and corporate governance across different countries (Musteen et al., 2010), so more researches are called for investigating the relationship between the entry mode and corporate governance. Then we will develop the framework under the corporate governance theory and network perspective to analyze the FDI entry mode choice of Chinese firms.

Specifically, this paper unfolds as follows. Firstly, we will integrate the current researches to summarize the characteristics of FDI entry modes, including the greenfield investment, acquisition, and joint venture; Then we will depict the specific traits of Chinese FDI; After these preparations, we develop the propositions about how Chinese firms choose different entry modes and integrate into the framework based on the corporate governance theory and network perspective; At last, we will discuss the conclusions and limitations of this paper.

2 Entry mode

Entry mode, as an institutional arrangement for organization and conducting international business transaction (Anderson, 1997) has been viewed of high strategic importance, which is greater part of top managers' major decisions related to foreign market entry.

The main reason we chose these three entry modes (greenfield investment, joint venture, and acquisitions) in this study is that they are strategic alternatives along a continuum of control right modes, namely greenfield investment represent greater control at one end of the continuum, while joint venture represent less control at the other end, and in the middle of the spectrum is the acquisition, which is also the obvious difference between joint venture and acquisitions.

About the terminology definition, the acquisitions stand for the purchase of stock in an already existing company in an amount sufficient to confer control (Kogut and Singh, 1988), along which study, we draw the explicit boundary of acquisitions consist of a controlling equity share with the remaining shares dispersed across many investors. Joint venture is defined as the pooling of assets of two or more firms in a common and separate organization by two or more firms (Kogut and Singh, 1988; Chang and Rosenzweig, 2001), while Greenfield investments (or foreign start-ups) involve building an entirely new organization in a foreign country from scratch.

There have been researches analyzing the entry mode characteristics but from different dimensions separately. For example: normative decision theory suggests that the choice of a foreign entry mode should be based on the trade-offs between risks and returns (Agarwal and Ramaswami, 1992), while Rhoades (2001) analyzed the international entry mode choice in terms of cost (resource commitment), control (level of ownership), and risk (related to the level of resource committed and the complexity of the environment entered). Similarly, Herrmann and Datta (2006) differs these three entry modes in four important ways, including control, risk exposure,

resource commitment, and the opportunity to access to the local partners' knowledge.

Based on the extant literature, we summarized the eight different aspects of the entry modes. Entry mode choice decisions generally involve a compromise among these eight attributes. (1) Speed of getting up and running; (2) degree of control; (3) risk; (4) integration; (5) access to complementary capabilities; (6) access to intangible assets that often slow and difficult to build; (7) flexibility; (8) Learning opportunities. These three entry modes have distinct characteristics, theoretically, which will be chosen by the managers according to their different objectives (Meyer et al., 2009).

Table 1. The compromise attributes of entry modes

Entry mode	Acquisitions	Joint ventures	Greenfield investment
Speed	Medium	High	Low
Control	Medium-High	Low-Medium	High
Access to flow of complementary capabilities	Low-medium	High	Low
Access to intangibles	High	Medium	Low
Risk	Low-medium	Low	High
Integration	Medium	Low	High
Flexibility	Medium-Low	High	High
Learning Opportunities	Medium	Low-Medium	High

Although acquisitions offer a speedy establishment or local presence in a foreign market, (Child and Rodrigues, 2005), they may be exposed with risks of overpayment, inability to fully assess the value of acquired assets, and post-acquisition integration failures because of cross-cultural differences (Chang and Rosenzwig, 2001; Dikova and Witteloostujin, 2007). Also through acquisitions, firms could acquire new intangible resources, like technological skills, eminent brand, and high-level management (Barkema and Vermeulen, 1998), which exactly are the important assets Chinese firms need.

Greenfield investments offer the greatest control to the investing firm, the higher degree of managerial autonomy and full control over local operations, yet often require the longest establishment period, and require the greatest contribution of know-how (Chang and Rosenzwig, 2001; Dikova and Witteloostujin, 2007), on the other hand higher investment and higher commitment with new plant also makes the greenfield a riskier entry mode, facing the uncertain legal and economic environments (Wooster, 2006). Greenfield investment is considered as a route that maximizes managerial control and the possibilities for global integration (Child and Rodrigues, 2005). Greenfield investors may find it harder to integrate into local business networks, which may be vital for business success, because networks are extensively used where formal institutions are weak (Peng and Luo, 2000).

When firms want to enter the foreign market quickly, joint ventures are preferred to choose to make full use of the local supply chain and distribution networks (Meyer and Estrin, 2001). As JVs are a way to draw on the resources of a local partner, hence

involve relatively lower investment and risk (Agarwal and Ramaswami, 1992; Chang and Rosenzwig, 2001). In addition, a very important characteristic of JVs is that the shared ownerships enable firms to tap into valuable resources of a local partner (Dikova and Witteloostujin, 2007), which will provide a more effective channel for the transfer of tacit knowledge, not just in production and distribution but also in other areas where internationally competitive standards need to achieve (Inkpen, 1995; Simonin, 2004). Moreover, JVs provide the ways to share complementary but distinct knowledge, which would not be shared otherwise (Kogut and Singn, 1988). On the other hand, just because of this shared ownership, it's at times hard for firms to coordinate with partners whose interests and goals may diverge. In conclusion, joint venture is the entry strategy that would be faster, more flexible, less risky and less costly than internal start-up (greenfiled investment) and acquisitions (Pearce and Hatfield, 2002). The comparative analysis detail shows above.

3 Trend and characteristics of Chinese

The editors of Academy of Management Journal (AMJ) summarized the international management research in AMJ, and found that almost one-third of the 269 international studies between 1970 and 2004 involved collecting data from North America, ranking first, and then followed Japan, the United Kingdom, and the Netherlands (From the editors, 2005). So there are limited researches about Chinese firms' internationalization, within the entry mode research field even researches related with China, it is considered as the host country (for example, Tse et al., 1997; Isobe et al., 2000; Pan and Tse, 2000). To our knowledge, there have been some case and theory studies about Chinese firms' internationalization, but obviously not enough, little is known about how Chinese firms actually make their first steps in outward FDI, namely, the choice of FDI entry mode (Cui and Jiang, 2009). We firstly describe the overall pattern of Chinese firms' OFDI, then summarize the differences between Chinese firms' OFDI and firms from developed countries.

3.1 Trend

Figure 1 depicted the Chinese firms' outward FDI development path from year 1979 to 2011. As we can see from the data, the amount of Chinese firms' FDI reached 2.7 billion dollars in 1990s from the scratch in 1970s and '80s. 1990 is the first very important point of Chinese OFDI development history, which means the rapid development for the first time (Lecraw, 1993; Tolentino, 1993). During this period Chinese firms were 'pulled' to invest abroad to access more market and technology (Yeung, 1999). After joining WTO, Chinese OFDI had been growing rapidly and continuously to reach 26.51 billion dollars in 2007, and doubled to 55.91 billion dollars in 2008. Though the global economy slows down because of the sovereign debt crisis and the turbulence in Middle East and North Africa, Chinese OFDI maintains growth after 2008.

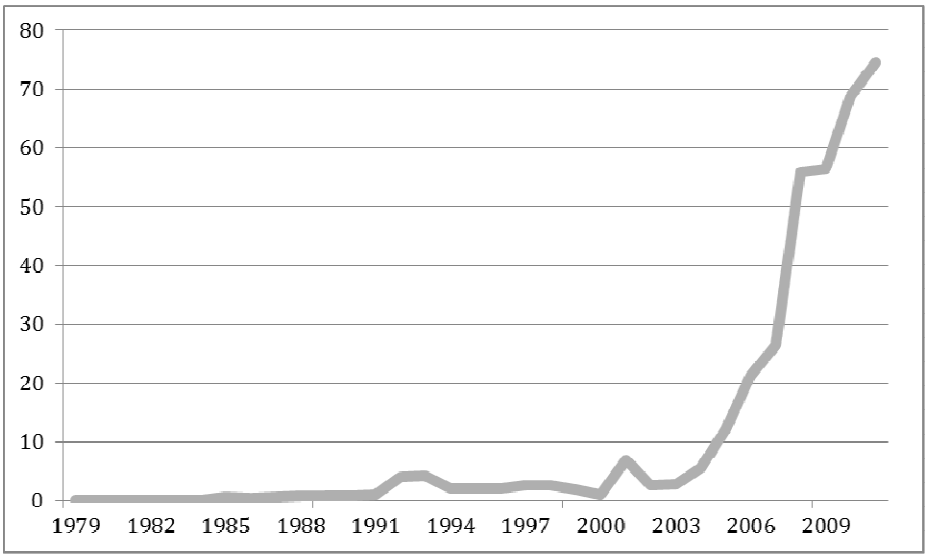
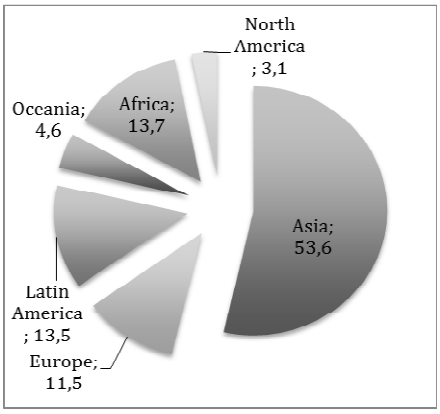


Fig. 1. Chinese FDI developing trend. (source: 2011 Statistical Bulletin of China's out ward foreign direct investment; unit: billion USD)

3.2 Location

When Chinese firms initially invest about, they mainly focus in establishing subsidiaries in the major ports and cities, like New York, Hong Kong, and London. With the developing of Chinese economy, the destinations of Chinese OFDI extended to more developed countries like America, Canada and Australia from originally confined in HK & Macau and other developing countries. Till now Chinese firms' OFDI have been through 177 countries and regions, occupying 72% of the global countries in total. But from the figure 2 & 3 showing, geographically the locations of Chinese OFDI are more concentrated. Specifically, either in terms of OFDI stock or the number of foreign subsidiaries, Asia is the most important destination. Besides the geographical reason, the similar culture and the ethnic network also attract Chinese firms' investment (Sikorski and Menkhoff, 2000).



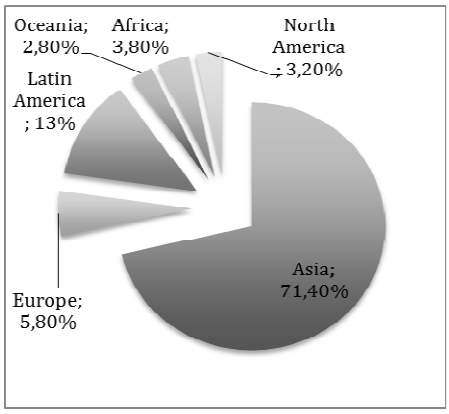


Fig. 2. (left). 2001 Chinese OFDI stock

Fig. 3 (right). 2011 Number of chinese foreign subsidiaries distribution

3.3 Ownership

Since China's reform and opening up, the government made the policy, in which public ownership plays the leading role and diverse forms of ownership develop side by side. And the 16th National Congress report points out: "help and encourage relatively competitive enterprises with various forms of ownership to invest to run enterprises abroad", which really stimulate the passion of different kinds of firms investing abroad. From table 2, we can see, not like before the state owned enterprises occupying the leading role in OFDI, but various types of firms starting to participate into this international business.

Table 2. 2011 Investors classification by registration type

Registration type	Number	Percent
Limited liability company	8136	60.4
State owned enterprises	1495	11.1
Private enterprises	1120	8.3
Company limited by shares	1036	7.7
Cooperative stock enterprises	535	4
Foreign invested enterprises	480	3.6
Enterprises with investment from Hong Kong Macao and Taiwan	320	2.4
Collectively-owned enterprise	130	1
Individual enterprises	110	0.8
Others	100	0.7
In total	13462	100

3.4 Differences between Chinese firms' OFDI and firms from developed countries

Especially within the context of firms in China, the core research issue in Chinese business is related to the roles played by the state-owned enterprise (SOE) ownership since the advent of communism (Ralston, et al., 2006). As one of the most important emerging economies, China presents a distinctive and highly dynamic institutional environment (Meyer et al., 2009; Peng et al, 2008), and remains a political economy despite the development of a market system (Child and Tse, 2001), which intrigued the scholars to pay more attention to these differences from developed economies. But very few researches analyze the relationship between Chinese firms' ownership and entry mode choice.

From the developing trend of Chinese OFDI, we can tell the speed of Chinese firms' internationalization is accelerated (Mathews, 2006), since they try to catch up the firms from developed countries. And compared with the firms from developed countries in the international markets, Chinese firms not only need to face the 'liabilities of foreignness', they also confront the disadvantages from 'liabilities of newness' (Guillen and Garcia-Canal, 2009), which made Chinese firms' international entry mode choice different firms from developed countries.

4 Framework of entry mode choice

4.1 Ownership

As we summarized in the literature review, extant entry mode researches grounded in several main theories, like transaction cost analysis (Brouthers and Hennart, 2007; Zhao et al., 2004), resource-based view (Barney, 1991), institution-based view (Brouthers, 2002; Davis et al., 2000; Oliver, 1997), and integrated model, including Dunning's eclectic framework (Dunning, 1988, 1993) and multilevel framework involved firm, industry, and country specific factors (Pan and Tse, 2000). The premise of these theoretical approaches is that the entry mode choices made by the ideal best decision based on these theories considering the compromise attributes of different entry modes. However, in the real business world, foreign entry mode decisions are always complex, facing incomplete information and considerable uncertainty, moreover the decision-makers always own their own different self-interest, goals and preference, so may choose the different entry mode even facing the same situation (Musteen et al., 2010). From this perspective, since different types of owners have different self-interest, risk preference and decision-making horizons, the entry mode choice must be influenced by the firm's ownership structure (Wright et al., 2005; Hoskisson et al., 2002).

From the agent-theory perspective, most extant researchers analyzed the entry mode preference of the manager form the risk dimension. Some studies stated that managers have shorter time horizons. The equity ownership amount means most of their wealth, and the firm managers would have to take the cost (risk) of failure, in which the possibility exists that they will choose a entry mode with less risky strategy even

though there still are other strategies available might on average have higher financial payoff, so they will be more risk-averse (Filatotchev et al., 2007; Pan et al., 1999; Woodcock et al., 1994). However, Fama and Jensen (1983) suggested that because of the limited financial stake between the manager and the firm, the agency problems are more likely to happen, which means that they prefer to apply some risky strategy. So there are still no consistent opinions about the risk preference on the entry mode choice of managers.

However, as we said before, the entry modes are the multi-dimensions' phenomenon, which means that we need to consider from more perspectives about the concept of entry modes. Apart from the risk dimension, the 'control' is also the very important normal aspect the managers will analyze. For the public firms, since the managers have relative less power to the firm, they would not consider the degree of control to the subsidiaries as their important objectives. Besides, the managers in Chinese firms always engaged in the day-to-day running of the company, so mostly they have been absorbed by these things leading to have limited time and capacity to monitor the overseas venture (Filatotchev et al., 2007). Plus the foreign market situation is not where they are familiar with, so facing the potential dangers, they will avoid choosing high commitment entry mode, which needs more control and integration to put in. In a word, for public firms, managers prefer to choose the less risk, less control and integrated ability needed entry mode while entering into the foreign market.

The mangers of public firms also pay much more attention on the strategic dimensions of the entry modes. Firstly, the speed of investing is very important. That's because the mangers have to show the achievements they have made timely. And there is much pressure on the managers from the shareholders that they need to make good performance immediately to show their abilities. That means when their equity ownership in the firm is limited, the managers pay more attention on the fast effect strategy. From the opposite, when the managers hold a significant proportion of a firm's stock, they are more likely to focus on and emphasize investments that maximize long-term shareholder value (Datta et al., 2009). As we discussed before, for Chinese firms the international FDI is the important path to get the knowledge and capabilities. For managers of the public firms, though this dimension is not the priority, this is better for Chinese firms' development.

Proposition 1a: The larger the public ownership of Chinese firms, the more likely they will choose joint venture over Greenfield investment or an acquisition.

Compared with public firms, many state-owned firms enjoy access to state assets and intellectual property at a discount, and also the firms can achieve financial and resource support (Williamson and Zeng, 2007). Warner et al. (2004) contend that the firms in China supported by state's sponsorship and funding support are always entering and penetrating a host country through the frequent acquisitions. Because of this supporting, the state-owned firms have high risk tolerance.

Moreover, in China every listed firm's board has a parallel authority structure – the firm's Party Committee – headed by its Party Secretary. Real power and important decisions are through the party channels, leaving the board and formal corporate top executives scant real authority (Morck et al., 2008). With the increasing of the percentage of the state-owned share, the attention will be put by the government and

the Communist Party of China. So the state-owned firms put more attention in the control of the overall situation. Besides, normal firms always consider a decision from the economic view, however state-owned enterprises have to incorporate the aims of building national image, access to the key resources, enhance national pride and so on. Researchers have documented that there is natural tendency to seek national pride in investment decisions among the developing countries (Hope et al., 2010). There are always accompanying the huge media frenzy, political interference, and nationalistic talk during some of the bids originating from the developing countries. Compared with the other firms, the state-owned firms will start the new company in overseas to build Chinese brand. So the state-owned firms prefer to acquire higher control and integration in the FDI, and also need to build the 'flagship firm' in the international markets to convey the image of China. But the state-owned companies will consider decisions in the long time, not like the managers in firms more likely to pursue short effect.

Proposition 1b: The larger the state-ownership of Chinese firms, the more likely they will choose greenfield investment or an acquisition over a joint venture.

4.2 Network

With the modern business environment becoming more and more competitive, networks have played increasingly important role for firms to seek opportunities to secure information and access knowledge (Zaheer et al., 2000). Internationalization occurs as a result of multilateral externalization through business and social networks rather than through internalization (Malhotra et al., 2003), which would influence the initial market entry and entry mode choice (Coviello and Martin, 1999).

Institutional research suggests that network linkages are important to many firms in Asian newly industrialized economies and other emerging markets (Filatotchev et al., 2007). Especially for Chinese firms, China has the distinctive cultural and institutional legacy, including the tendency to rely on close personal relationships in business transacting (Chen and Chen, 2004), so when considering the international strategy, Chinese firms' decision must be influenced if there are the networks between self and companies in host country. The network always could be divided into two directions, namely foreign firms seeking relationship with Chinese firms in China, also called 'passive' inward internationalization for Chinese firms; and existing local relationship, invested 'actively' in advance.

Inward internationalization. Facing the successful multinationals, Chinese companies as the latecomers confront a number of important handicaps, including limited marketing capability, weak distribution and brands, a paucity of proprietary technology, limited breadth of capabilities, and lack of management depth, which will usually put the end to the internationalization goal of Chinese firms. However, the globalization characterized as 'the world is flat' weakened these barriers and has also opened the new gateways and brought the new opportunities for the Chinese firms (Williamson and Zeng, 2007).

In China, the Inward FDI preceded the outward FDI, and inward FDI has been used as ways for Chinese firms to prepare to become multinational corporations in the competitive global market by the Chinese government, as early as 1978 (the

beginning of Chinese economic reform) (Yang et al., 2009). Since 1979, inbound FDI has been legally permitted in China. In just 25 years, FDI inflow rose from US $ 2.43 billion per year in the early 1980s to US $ 153.47 billion in 2004, and China became one of the world's largest FDI recipients since 2002 (The US China Business Council, 2005). Since then the long-term contracts or partnership with foreign companies through inward internationalization has become the important means for Chinese firms to learn about international knowledge and experience as a preparation for internationalization (Child and Rodrigues, 2005).

The usual inward internationalization paths are OEM (original equipment manufacturing), ODM (original design manufacturing) or OBM (original brand manufacturing), licensing of foreign technology, outsourcing, modular products and services, which can stimulate Chinese firms' (emerging market firms) outward internationalization efforts (Luo and Tung, 2007). More specifically, OEM, ODM or OBM arrangements provide Chinese firms the opportunities to preserve the own identity, achieve economies of scale, and gain an international reputation while other paths involve Chinese firms into the closer network with the foreign multinationals, offering the highly effective mechanism for the tacit knowledge transfer (Luo and Tung, 2007). Below we will analyze the general spillovers from the inward internationalization.

The first one is the demonstration effect, in which domestic firms, could increase their own productivity by observing these firms' technologies and management practices and imitate them in their operations through exposure to foreign firms' activities (Zhang et al., 2010; Blömstrom and Kokko, 1998). According to this logic, the inward internationalization could provide Chinese firms' the chances of the cooperation with foreign multinationals which will be the source of the operational, organizational transfer of the competencies and knowledge about how to deal with 'outward' internationalization (Child and Rodrigues, 2005).

The second one is the accumulated financial and operational assets. Young et al. (1996) also documented that during the inward internationalization, local companies could accumulate considerable financial and operational assets, upgraded technological and process management skills, and developed unique capabilities and learning experiences.

The third one is the employee turnover. When employees from foreign firms take jobs in domestic firms, or the foreign firms need to hire domestic firms' employees, the domestic firms also could get to know the details about the foreign firms' technologies and management practices through the employees turnover, then create positive spillover effects (Zhang et al., 2010).

The fourth one is the learning effect. Chinese firms can strengthen their international experience and competencies through learning from multinational enterprises involved in this inward internationalization relationship (Child and Yan, 2001; Guthrie, 2005), which encourage the firms to commit resources to foreign markets, manage the risks of expansion and cope with the liability of foreignness (Guillen and Garcia-Canal, 2009). Many Chinese firms have learned and appreciated the American way of doing business through their U.S. partners, which have been operating in China for years. This may assist Chinese firms to adapt themselves to the United States economy and American business operation. So this international preparation

including the experience and competencies will reduce the potential risk they perceived, improve their own integration and control ability, making the firms prefer to choose more commitment and risky entry mode.

Besides, the competition brought by the foreign companies and the network also could help domestic firms to increase the competitiveness. The increased competition that accompanies inward FDI can force domestic firms to increase their productivity by updating manufacturing technologies and adopting advanced management practices to meet this competitive challenge (Blömstrom and Kokko, 1998); Over the two decades, foreign multinationals also helped local partners intensify foreign capital and international contacts and networks through various partnerships (Yang et al., 2009).

Galanz, used to be a town and village enterprise based in Shunde, Guangdong Province interpreted the path from OEM (inward internationalization) to successful outward internationalization. After years of OEM suppliers for many different international brands, Galanz accumulated the technology, management philosophy, international experience, brand reputation and ect, laying the solid foundation for the future development (www.galanz.com/news, September, 16, 2009), so when they entered in foreign market, they prefer to choose more commitment, more risky but relative more control and integration demanded. Galanz invested US $ 20 million to start up an R&D centre in Seattle, opened a brand new development centre in Seoul in 2006 (www.galanz.com/news, September, 16, 2009).

BAW (Beijing Automobile Works Co. LTD) purchasing the Saab (Svenska Aerophan Aktiebolaget) on 14th December, 2009, surprised the worldwide, and drew the attention. BAW is a historical carmaker in China, who made the first can in China totally independently, but it did not develop very well next years. Since the 'outward policy' supported by Chinese government, BAW cooperated with Hyundai and DaimlerChrysler in China, which provided the opportunities for BAW to learn and grow. This also encouraged BAW to purchase the Saab. (www.baw.com/news, 'Is it the independent making cars for BAW remodeling Saab?')

Proposition 2a: The longer the Chinese firms involved in the inward internationalization, the more likely they will choose Greenfield investment or an acquisition over a joint venture.

Proposition 3a: The positive relationship between the state-owned ownership and the Greenfield investment and acquisition in China is the stronger for firms with longer inward internationalization length and stronger local network strength.

Outward local network. The opposite direction of the 'inward' internationalization is the active internationalization, means that existing local network before firms' entry. Firms are exposed on the greater risk, and more control and integration ability demanding, while entering into the new foreign market, especially more distant markets, geographically and culturally (Filatotchev et al., 2007). But this perceived risk may be mitigated by existing local network, and firms also could improve their control and integration ability to local firms, since they can know more about local firms and get a lot of benefits from the local network, such as the provision of relevant information on local business opportunities, access to key local contacts, knowledge and information in a particular destination, experience in dealing with

local officials and the management of local labor (Child and Rodrigues, 2005; Filatotchev et al., 2007).

As Chen (2004) argued, Chinese firms tend to rely on close relationships in business transacting, so the local network effect will be more obvious for Chinese firms. The specific-location network does bring much more information about the local environment, policy and local firms, and reduce the possibility of potential opportunistic behavior. All these effects will encourage Chinese firms to choose more risky entry mode while deciding to enter the foreign market.

Proposition 2b: The stronger the location-specific network the Chinese firms involved in, the more likely they will choose Greenfield or an acquisition over a joint venture.

Proposition 3b: The positive between the public ownership and the joint venture in China is weaker with longer inward internationalization length or stronger local network strength.

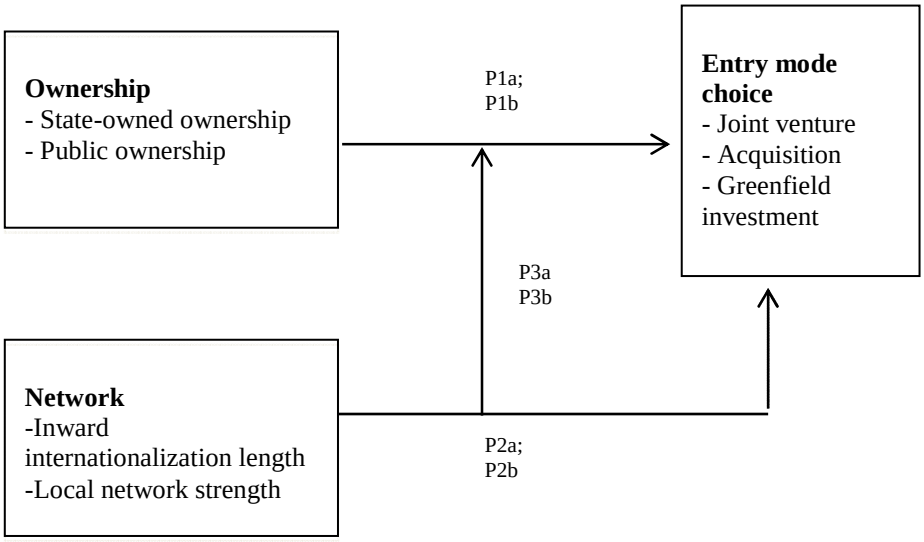


Fig. 4. Entry mode choice framework

5 Discussion and limitation

Chinese firms' outward FDI has attracted more and more attention across the world. In order to explain how Chinese firms choose the entry mode, we firstly summarized the 8 characteristics of three different OFDI entry modes; then based on the national data, we depicted the trend and characteristics of Chinese OFDI to find the differences between Chinese firms' OFDI and firms from developed countries; After all these preparation, we analyzed the mechanism of Chinese firms' OFDI entry mode choice from ownership and network perspectives, further integrated both views into a framework.

Academically, facing the gap that current empirical research results based on the

'tripod' theories are inconsistent, this study introduced new perspectives, agent theory and network perspective to analyze firms' entry mode choice, which would help us know more aspects of the entry modes. And recently more and more firms from developing countries have begun to invest in the international markets, this study also shed lights on why and how they conduct investments abroad.

Practically, our research provide a guide for firms from developing countries, which are considered as the latecomer and less competitive in the international markets how to succeed in investing abroad. Firms should choose their matched entry mode based on their ownership situation, and make full of their network, including inward FDI and outward FDI to prepare well for the next investment.

Our study suffers from some limitations noted, which also are future research implications. Obviously, this study only covers one time point, instead of using a longitudinal approach. Based on Uppsala theory, with the experience accumulating firms' international strategy will change. So Future research could expand our research design and study these international processes in a longitudinal perspective. Also future research could develop our paper by exploring the motivation, and location choice of firms' FDI, since it has been proved that the core strategies of FDIs, including motivations, location choice, and entry mode are related. So analyzing these core strategies together will help us know the mechanism of firms' international investment better.

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Knowledge creation in small construction firms

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Abstract. Studies on knowledge creation are limited in general, and there is a particular shortage of research on the topic in small and medium-sized enterprises (SMEs). Given the importance of SMEs for the economy and the vital role of knowledge creation in innovation, this situation is unsatisfactory. Accordingly, the purpose of our study is to increase our understanding of how SMEs create new knowledge. Data are obtained through semi-structured interviews with ten managing directors of German SMEs operating in the construction industry. The findings demonstrate the influence of external knowledge sources on knowledge creation activities. Even though the managing directors take advantage of different external knowledge sources, they seem to put an emphasis on informed knowledge sources. The study´s findings advance the limited body of knowledge regarding knowledge creation in SMEs.

Keywords. Knowledge creation, small and medium-sized enterprises (SMEs), knowledge management, knowledge, construction industry.

1 Introduction

"…management scholars today consider knowledge and the capability to create and utilize knowledge to be the most important source of a firm's sustainable competitive advantage" (Nonaka et al., 2002, p. 41).

As the opening citation indicates, knowledge has become an essential source of value generation and competitive advantage in post-industrial society (Barney, 1991; Spender, 1996). In order to survive in an ever-changing business environment, companies have to constantly create knowledge that is both similar and different from that of competitors (Tolstoy, 2009). Allard (2003) stresses that "knowledge creation plays a vital role in innovation, a process that is important because it facilitates an organization's ability to keep pace with a dynamic environment" (p. 368). According to Du Plessis (2007), innovation is "the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market driven products and services" (p. 21). Therefore, a firm's capacity to continuously create new knowledge can be regarded as determining factor for its competitiveness.

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While knowledge is considered the most important source of a firm´s competitive advantage, the study of knowledge creation in general is lacking, particularly with regard to definitions and measures (Mitchell and Boyle, 2010). This refers to all organizations, regardless of size. If one addresses the study of knowledge creation in small and medium-sized enterprises (SMEs), however, there is a particular shortage of research. For example, Durst and Edvardsson (2012) who conducted a literature review on knowledge management (KM) in SMEs identified only five papers on the topic of knowledge creation. Against the prevalence of SMEs, this situation is unsatisfactory. Additionally, as continuous knowledge creation is viewed as a fundamental basis for innovation (Amalia and Nugroho, 2011), a better understanding of the actions undertaken by SMEs would be helpful.

Bearing this in mind, the purpose of our paper is to investigate knowledge creation in SMEs. More specifically, we analyze which knowledge creation activities/actions are undertaken in small German firms operating in the construction industry. Since the construction industry plays a vital role in Germany and is mainly represented by SMEs we consider it to be useful for our research.

The present paper is organized as follows. In section 2, the literature related to the research aim is briefly reviewed. Section 3 then describes the method employed to come close to the research problem. Following this, the findings are outlined, and in the final section, the conclusion and study's implications are presented.

2 Theoretical background

2.1 Knowledge creation

Knowledge creation refers to ways through which the construction of new knowledge is concerned. It refers to activities related to the determination of required knowledge and activities that are implemented to acquire the needed knowledge (Amalia and Nugroho, 2011). Knowledge creation in companies can be supported by, for instance, giving organizational members time to experiment (Gupta and Govindarajan, 2000). Additionally, knowledge sharing can enable organization members to create new knowledge as well (Amalia and Nugroho, 2011). Thereby, knowledge is not only internally produced; external knowledge sources need to be considered as well.

The most influential theory of knowledge creation belongs to Nonaka and associates (Nonaka and Takeuchi, 1995; Nonaka and Konno 1998; Nonaka et al., 2002), who argue that the interaction between tacit and explicit knowledge via socialization, externalization, combination and internalization (summarized under the term SECI), leads to the creation of new knowledge. A shared place is also considered important for knowledge creation, whether it is physical, such as an office, virtual e.g. email or teleconference or mental, such as shared experiences or ideals. Ba provides a platform for advancing individual and/or collective knowledge. Knowledge resides in Ba and is intangible. There are four groups of Ba: originating Ba, dialoguing Ba, systematizing Ba and exercising Ba. Each one of these supports a particular mode of knowledge conversion in the stages of the SECI process.

Additionally, the link between learning and knowledge creation is quite common in the literature so that these are often used as synonyms. Theories of learning and knowledge creation have been developed in two different disciplines: (i) knowledge creation theory within KM, (ii) and learning theory within education and organizational studies (Jakubik, 2008). Argyris (1999) sees organizational learning as a process of detecting and correcting errors. This would comprise a proper diagnosis of the error´s cause, along with its correction, so that organizations can learn from experience and implement suitable actions intended to prevent a repetition of these errors. In this context, Allard (2003, p. 375) says "often this leads to identifying a need that requires new knowledge to be created to answer the need". Nonaka and Takeuchi (1995) argue that knowledge creation involves interaction between two kinds of learning: obtaining know-how to solve specific problems based upon existing premises, and establishing new premises to override existing ones. Ueki et al. (2011) stress that providing employees with challenging initiatives, and systematically applying comprehensive human resources development (HRD) practices, such as cross-functional projects, job rotation, career development, group training and e-learning, can contribute to a stimulation of knowledge creation in organizations. An organization's success and ability to innovate and develop new routines is tied to its capacity for higher-order learning (double-loop), while lower-order learning (single-loop) potentially limits the creation of new knowledge and ways of working (Spicer and Sadler-Smith, 2006). Also, triple-loop learning may provide an opportunity for innovation, although it is rarely used in reality. This is about combining all local units of learning in one overall learning infrastructure, and developing the competences and skills to use this infrastructure (Romme and van Witteloostuijn, 1999).

Former research showed that new knowledge can emerge by accident (e.g. the discovery of penicillin) or by deliberate discovery following a gap in the literature and in corporate practice (Allard, 2003). Furthermore, new knowledge can generally emerge from new ideas or by emergent internal or external needs. New ideas are often transferred to the organizations via suppliers, professional bodies, consultants or research literature (external influences) or they stem from internal creativity and inventions. New knowledge also originates from needs and pressures from customers, competition, legislation and so on (external forces), or it may arise from perceived problems and opportunities identified by the staff and managers of organizations (Daft, 2007; Hughes et al., 2009; Sparrow, 2005). Improving brand value and attaching importance to customer satisfaction also fosters knowledge creation (Ueki et al., 2011).

KM tools can also assist knowledge discovery and knowledge creation through: (i) Data mining (i.e. data cleaning, data analysis, model interpretation and integration of results) (Jasahapara, 2011); (ii) KM-tools such as knowledge portals and groupware are said to contribute to knowledge creation (Ueki et al. 2011); (iii) Knowledge maps that can provide common context regarding ideas, concepts and mental models for organization members in an explicit visual model (Eppler, 2003); (iv) and KM 2.0 tools (e.g. blogging, wikis, video casting) that help firms improve their products. In this case, we may talk about "outside innovation", where customers and the "crowd" take on a substantive role in the innovation process by testing ideas and giving feedback at the developmental stage (Ribiere and Tuggle, 2010).

Organizational culture can either facilitate or strain knowledge creation (Migdadi, 2009). A company culture characterized by a high degree of change and flexibility will therefore have more positive effects on knowledge creation than cultures marked by stability and formalization (Kayworth and Leidner, 2003).

Mitchell and Boyle (2010) noted that former research has analyzed knowledge creation as a process, output and outcome. The process perspective assesses the steps or activities undertaken to create new knowledge, such as the use of metaphors to externalize knowledge. As an output, knowledge creation is measured in terms of an immediate product of the knowledge creation process, usually reflecting a significant enrichment of existing knowledge, such as a representation of a spoken idea. Knowledge creation as an outcome is measured in terms of a value-adding object, i.e. a new service, a changed routine or a product prototype. Here, the interactive process of knowledge creation, knowledge application and innovation is quite prevalent (Tödtling et al., 2009). Consequently, systematic activities related to knowledge creation can enable firms to meet the need for continuous innovation (Popadiuk and Choo, 2006). Chen and Huang's (2009) study underlined the positive effect of knowledge creation on innovation performance.

2.2 Knowledge creation in SMEs

Many smaller firms have a flat structure and an organic, free-floating management style that encourages entrepreneurship and innovation. They tend to be informal, non-bureaucratic and with few rules. Control tends to be based on the owner's personal supervision and formal policies tend to be absent in SMEs (Daft, 2007). In addition, in many smaller firms the owner-managers take on a central position (Bridge et al., 2003). In such an environment, it is not uncommon for the processes of business planning and decision-making to be limited to only one person (Culkin and Smith, 2000). This centrality also signifies that these people are particularly responsible for the recognition of the KM-related benefits, which support the firm's operations. However, SMEs' day-to-day business operations specifically require close attention (Hofer and Charan, 1984). This very often results in situations where owners or managing directors have insufficient time for strategic issues. This, in conjunction with lack of financial resources and expertise (Bridge et al., 2003), very often results in most knowledge being kept in the minds of the owner and some key employees, rather than physically stored or shared through substitution arrangements (Wong and Aspinwall, 2004).

Previous research on KM in SMEs has shown many differences compared to larger firms. Most SMEs have no explicit policy targeted at strategic KM, and they tend to treat KM on an operational level (i.e. systems and instruments) (McAdam and Reid, 2001). SMEs tend to place more emphasis on the management of tacit knowledge than larger firms (Corso et al., 2003) do. The SME sector appears to be less advanced in terms of knowledge construction, having a more mechanistic approach to this concept and relying less on social interaction (McAdam and Reid, 2001). Managers in smaller firms even tend to prevent outflow of knowledge from the company and thereby block knowledge sharing (Beijerse, 2000). Hutchinson and Quintas (2008) found that certain processes and means are given within SMEs, indicating that they do understand knowledge management, but it mostly happens in an informal way.

As resources are scarce in SMEs, knowledge is likely to result from secondary data (e.g. trade journals, sector research, conferences and professional magazines) or from personal contacts (Egbu et al., 2005). Knowledge acquisition activities in SMEs are concentrated in a few individuals, primarily managers, who have to divide their attention over several tasks (Lowik et al., 2012). In addition, as systematic knowledge search and creation will be more expensive compared to informal meetings with suppliers or customers, it is likely that the latter will be favored by SMEs (Cegarra-Navarro and Martínez-Conesa, 2007).

2.3 The construction industry in Germany

The industry contributes around 11 per cent of gross domestic product (GDP) and employs around 4.7 million people (12 per cent of total employment in Germany) (Wertschöpfungskette Bau, 2013). The German construction industry is predominately characterized by SMEs, i.e. 99.9 per cent of all companies are SMEs (Söllner, 2011). Whereas the majority of these SMEs are local/regional-oriented firms having a focus on private housing, local civil engineering and housing renovation (Roland Berger, 2011). One in five companies offers vocational training.

2.4 The construction industry and knowledge creation

The construction industry used to be regarded as somewhat conservative (Maqsood and Finegan, 2009). Growing challenges in the business environment due to fierce (price) competition and/or increased requirements on the part of the customers have caused many firms to reconsider their past practice. This development generally calls for a better management of knowledge within the construction industry (Hari et al., 2005). Bigliardi et al. (2010) summarize the following factors, which underline the importance of KM in project-based organizations: “the turbulence of the construction industry, where the demand is generally characterized by low predictability; the temporal and economic relevance of each project; the uncertainty that characterize the realization phase, mainly related to the heterogeneity of the technological processes involved and to the site location; the low standardization of the construction product and process; and the management and organizational firm’s complexity” (p. 20).

Knowledge creation activities may play a particular role with regard to firm survival (Egbu et al., 2005). Additionally, firms operating in the construction industry are people-reliant (Bishop et al., 2008). Consequently, another reason is there as to why construction firms should put an emphasis on KM activities. Considering the nature of SMEs and their reliance on people, one may expect construction companies to be rich in tacit knowledge, so providing a huge potential for knowledge creation and innovation (Du Plessis, 2007). On the other hand, the situation suggests that KM activities in general may better work if the emphasis is on people-oriented activities rather than on IT-oriented aspects (Bishop et al., 2008). With regard to the latter, the literature suggests that the construction industry is reluctant, even though more and more actors are recognizing the benefits of IT for successful KM (Yun et al., 2011).

As the construction industry is a project-based industry (Maqsood and Finegan, 2009), projects are often unique which require in turn a new set of knowledge and/or skills. Consequently, learning in the sense of knowledge creation as well as the

development of existing knowledge is a key objective (Ribeiro and Ferreira, 2010). Moreover, taking advantage of knowledge from prior projects may help the firms to improve the execution of following projects (Maqsood and Finegan, 2009). Given the growing complexity of projects, a number of different actors are involved; therefore, knowledge sharing and knowledge transfer is important (Yun et al., 2011). On the other hand, the involvement of different actors also forms the potential for new knowledge sources and innovation (Du Plessis, 2007).

The study of KM activities in the construction industry in general is rather new (Maqsood and Finegan, 2009). Yet, it is expected that KM could "enhance individual, group and organizational learning, improve information circulation, and even support innovation" (Ribeiro and Ferreira, 2010, p. 362). Against the background of the industry´s contribution to employment in many countries, more research is needed that aims at helping the industry to better manage its knowledge. As outlined above, the intense competition in the (German) construction industry as well as the industry´s project-based mode of operation make permanent knowledge creation activities essential.

A literature review resulted in a few articles that addressed knowledge creation in construction firms. Fong and Choi (2009), for example, investigated knowledge managing activities/actions undertaken in quantity surveying firms from Hong Kong. Findings related to knowledge acquisition suggest that external sources do not play a critical role as a means to new knowledge. The firms seem to prefer the training of own staff over hiring external staff in order to solve possible knowledge gaps. With regard to internal knowledge acquisition, some firms make use of job rotation, the transformation of valuable knowledge into writing in the case of departing staff, and experience evaluations at project conclusion. In terms of knowledge creation, the findings indicate that the organization members are encouraged "to suggest alternatives methods of performing the same/similar task(s), and to identify best practice for sharing" (p. 117). Therefore, they are permanently working on further developing existing knowledge. Additionally, staff is encouraged to evaluate mistakes. This is explained by reputational and liability issues. Knowledge sharing (distribution) in these companies mainly addresses the transfer of tacit knowledge. For example, many firms reported that experienced staff is encouraged to mentor new or less developed staff. In addition, knowledge gained from projects is made available throughout the firms. It is shared by daily interaction with colleagues. Moreover, many firms stated that staff with specific skills is assigned to specific projects.

Ribeiro and Ferreira (2010) studied ways by which construction projects are prepared. The findings from five case studies indicate that the informants involved did not make use of experiences for the preparation and execution of new projects. Lessons learned, errors/mistakes etc. are not documented, and engineers working in construction sites often lack time or motivation to write down detailed accounts of problem solving solutions. Construction knowledge is shared and discussed personally among the different actors involved, yet is not documented for possible future use. With regard to the type of knowledge produced in projects, the informants stated that both tacit knowledge and explicit knowledge could arise.

Bigliardi et al. (2010) looked into the process of knowledge creation and transfer in construction firms. Using one case out of their sample, the authors illustrate how

other construction firms can better share knowledge from past projects for reuse in following projects. In the presented case firm, this was realized through the introduction of an information system. Findings suggest that the information system has contributed to cost-savings, reduced knowledge access and response time, errors and defects reduction, an improved firm image, reduced site set-up time while at the same time improved on-site productivity, and improved online call for tenders.

3 Research methodology

Given the study's aim, an exploratory (qualitative) research approach appears to be appropriate. A qualitative approach allows us to get closer to the participants and their way of thinking in order to scrutinize the entire research problem in depth (Maykut and Morehouse, 1994).

The companies selected for the study include smaller German firms operating in the construction industry. Because of the fact that we were not able to rely on a single database, we identified convenience sampling as a suitable sampling method for the study. Therefore, the firms were recruited through the researchers' informal and formal contacts. Semi-structured interviews have been conducted with the managing directors of the firms. The semi-structured approach is regarded as appropriate when very little is known about the subject in hand (Maykut and Morehouse, 1994). Ten firms have been involved in the study. An interview guide supported the interview process. All questions were open ended, underlining the paper's explorative character. The interview guide was tested with one managing director. The question wording was amended because of this step. The final interview guide focuses upon the following points: general facts concerning the business and managing director, issues related to determination of knowledge demand, knowledge creation, and knowledge sharing. This structure follows the three main activities relating to knowledge creation as suggested by Amalia and Nugroho (2011). The interviews were conducted in January 2013 and took place over telephone. The interviews lasted anywhere from 30 minutes to 1 hour, were recorded and later transcribed. Note taking after the interviews was used as a means to bring forward thinking and to write down seemingly important aspects related to the phenomenon under investigation.

Data analysis involved reading the transcripts several times to become familiar with the data. In addition, it helped to identify specific patterns of each transcript. Each transcript was then compared with the others, which allowed for cross-case analysis (Eisenhardt, 1989). This was conducted by two of the authors.

The characteristics of the interviewees and their firms are summarized in Table 1.

Table 1. Demographic characteristics of the participants

Interviewee	Legal form	Position	Year of foundation	Number of employees
1	Sole proprietorship	Managing director (MD)	1885	1
2	Limited company	MD	1970	30
3	Sole proprietorship	MD	1870	15
4	GmbH & Co. KG	MD	1933	60
5	Limited company	MD	1960	9
6	Corporation	MD	1980	4
7	Limited company	MD	1929	210
8	Sole proprietorship	MD	1979	7
9	Limited company	MD	1983	10
10	Limited company	MD	1982	6

4 Findings

4.1 Determination of required and/or new knowledge

This KM process focuses on activities that help to identify the knowledge necessary for the company as well as sources to acquire this knowledge. This activity also comprises the identification of already existing knowledge (Egbu et al., 2005). With regard to the findings, the informants identify new or required knowledge during personal discussions with different stakeholders such as architects, suppliers and customers. Journals, trade association releases and trade shows also fulfill this function.

Interviewee 7, for instance, sees the need for new knowledge in the context of the introduction of new processes. The people that work at the intersections (the link between new processes and existing work routines) are those individuals that notice whether the newly generated knowledge has been spread appropriately in the organization. The need for knowledge is discovered at construction sites when tasks can no longer be solved using the existing knowledge base. Furthermore, all types of problems can justify knowledge demand. Both outdated software, which must be internally adjusted, as well as new software whose introduction requires additional knowledge for the organizations employees have been mentioned in this context. Additionally, Interviewee 7 noticed that the signalization for the need for knowledge could also arise in situations that are not related to day-to-day business. This individual gave the example of a company anniversary where the company should present their innovations. Interviewee 4 confirmed that production processes are an area providing the basis for new knowledge relevant. Human-related issues can mean another area of knowledge demand. Three interviewees (3, 4 and 6) mentioned sickness and labor turnover as examples.

Interviewee 3 mentioned the changes in standards and „actual consulting requirements". Interviewee 3 additionally stated that the need for knowledge is discovered through "consistent double-checking". Interviewee 8 stated that the preparation phase is the stage in which (new) project-related knowledge is identified

conforming previous research (Ribeiro and Ferreira, 2010). Additionally, the interviewee makes use of professional journals for new information regarding the trade. Interviewee 9 reported that further training courses are occasions in which the need for new knowledge becomes apparent. According to interviewee 10, new knowledge identification results from an emotional state: "a feeling of being out of date".

4.2 Knowledge creation

The findings suggest that the informants regard knowledge as crucial resource of organizational development and they continuously carry out knowledge creation activities. For example, company 3 regularly conducts exchanges of experience, which contribute to knowledge creation. They occur internally via various paths. The entire workforce meets in regularly held "social rounds" (every six weeks) in order to jointly discuss "problems of a human nature" in an "enjoyable environment". The trainees are the only ones of the workforce who do not take part in these rounds. These meetings are meant to improve the employee network and increase the exchange of information and knowledge. Irregular meetings of project groups deal more directly with the professional problems. The employees come together for 15 minutes before the start of every workday – gratuitously – in order to discuss the project of the day. Each employee is expected to actively participate in the discussion, not only those employees from the project. The responsible employees later record these suggestions and compare them with the performance contents. The result of this process may lead either to savings in time or quality improvements. These discussions used to only be held between the managing director and foremen. This led, however, to the ignorance of suggestions and some employees feeling that they were being brushed off which resulted in lower motivation for the acquisition and sharing of knowledge. Similar approaches were found in the companies 6, 8, 9 and 10. The meaning of meetings (informal and formal) concerning knowledge creation is in line with previous findings (Fong and Choi, 2009).

A "conventional way" of knowledge creation in company 7 is to carry out workshops. The workshops consist of internal and external participants to allow the inflow of external perspectives. The remaining interviewees would not (companies 1, 5, 6, 8, 9 and 10) or only rarely (companies 2, 3 and 4) carry out workshops. Instead, they found informal gatherings to be of better use for knowledge creation. This finding points to size differences in SMEs (Perry, 2001).

An example of a knowledge creation outcome provided Interviewee 3 who mentioned the development of a new calculation software. All employees helped create a central control instrument for the capacity and time planning made from the standard software. "Everyone brought in their own knowledge and expertise. This brought happiness and strengthened the feeling of community. "

4.2.1 Collaboration as a means to knowledge creation

As stated by Du Plessis (2007) collaboration with external sources provide the basis for knowledge creation and innovation. The interviewees reported that they take advantage of a number of different external stakeholders, such as customers, suppliers, befriended companies etc.

With regard to customers, the companies have close relationships confirming an attribute that is associated with SMEs (Salavou et al., 2004). The knowledge creation process, which is started by special customer wishes, is largely of an operative nature. This means that solutions for the feasibility of current projects are created. Interviewee 3 mentioned, for example, the "increasing demand for energetic consulting". Only Interviewee 7 stated the implementation of additional instruments besides personal discussions in order to collect complaints and critique from customers. Knowledge creation processes are introduced based on the responses of an internally produced questionnaire as well as the use of telephone interviews. In the following improvement process, the customers are simply included in special cases. Interviewee 2 mentioned that the customers with an academic background would often like to be more strongly included "but then want to reinvent the wheel" and "in this fashion it all just goes up in smoke". Interviewee 4 added out a small amount of project-related customer wishes in their performance program, mostly as detailed changes or alternatives. Whereas Interviewee 8 told that his business model requires close customer relationships. Consequently, ideas from customers flow into knowledge creation. These ideas do not refer to technical solutions but to design issues, an emphasis which was mentioned by Interviewee 7 as well. Interviewee 10 underlined the benefit of having demanding customers who are willing to pay a premium for specific orders but also expect different solutions in return. On the other hand, interviewee 9 did not see the relevance of customers in knowledge creation, according to him "they lack the necessary understanding". This statement suggests that this interviewee is mainly interested in technical ideas rather than general ideas the firm could use to improve its offers.

Suppliers are used by all companies to update their technical knowledge. Occasionally the companies attend professional lectures offered by suppliers, but instructions from sales representatives on building sites or company headquarters are more common. The lessons from the sales representatives mostly address the products directly, whereas the instructions from the suppliers are often "broader" (Interviewee 3). Interviewee 5 confirmed this and mentioned that three of their employees had attended a fire safety training as a related example. Interviewee 2 additionally uses the suppliers´ sales representatives in order to detect "grey zones" in the professional knowledge of their employees. Interviewee 5 reported that employees schooled on the construction sites spread their newly acquired knowledge "as needed" (i.e. for similar problem situations) with their respective colleagues. In contrast, Interviewee 8 stated that suppliers are mainly sales people with no professional competences: "today they are selling cars and tomorrow fiberboards".

In addition to customers and suppliers, the interviewees named joint knowledge creation with cooperative partners. The findings points towards an expanded cooperation at the interfaces between subcontractors and contractors. Interviewee 1 mentioned a master roofer. They work together with the master roofer as a means to continually adjust the work process. The Interviewee further mentioned optimization attempts within the subsystem carried out together with subcontractors. Companies 4 and 7 go one step further. Companies of the respective confederations take on strategic partnerships. Interviewee 4 mentioned an example for knowledge creation in relationship with external business partners. They "completely redesigned the entire flow for the tile seals" in the sanitary construction together with three other

prefabricated house manufacturers. It met all of the current requirements and yet achieved a "technical simplicity" that made a cost effective implementation possible. This group performance was necessary, as the suggested solutions of the three competing prefabricated house manufacturers were much too expensive. Interviewee 7 painted a similar picture in reporting that experts from multiple prefabricated house manufacturers jointly worked on improved prefabrication techniques.

The craftsmen's guild and the construction association represent further external knowledge sources that are regularly used by interviewees 1, 2, 3, 5, 8, 9 and 10. These organizations especially offer commercial information and supply the companies with facts concerning new norms and juristic affairs. Companies 4 and 7 make use of corresponding organizations of the prefabricated house manufacturers. Interviewee 5 expands the firm´s commercial knowledge through discussions with tax consultants whereas Interviewee 8 turns to competent authors and surveyors of professional journals in order to discuss professional and technical innovation and problems.

Additionally, the interviewees 1, 2, 3, 5, 6 and 9 make use of personal (private) contacts to other SME managing directors. According to Interviewee 6, the initially private level of conversation usually switches over to professional discussions where knowledge "of all sorts" can be generated. This was confirmed by Interviewee 9 who stated that these discussions are used to work out solutions for problems on current construction sites. Interviewee 3's network includes craftsmen from the Lake Constance region. Meetings regularly take place, which include "intensive exchanges of experience". News and projects are discussed in detail among participants of the same trade. Interviewee 2 indicates that he was able to build up more trust with other craftsmen thanks to his membership in "Craftsmanship in Ravensburg". This led to the occasional exchange of commercial "know-how" whereby "small puzzle" knowledge could be generated. Interviewee 8 specified that he would hope for more regular meetings with other guild members, as current discussions seldom produce relevant issues regarding knowledge creation.

Interviewee 5 claims it to be "very beneficial that all members of the guild board are good friends. Everyone knows the special strengths of their colleagues and asks questions when needed." The meaning of such relationships, especially within one's own group, has been investigated in a British study of Hughes et al. (2009). This showed that the more successful companies tended to search for advice within their network concerning their core competencies. The findings also clarify the statements concerning the relationship between social capital and knowledge creation (McFadyen and Cannella, 2004).

4.2.2 Knowledge creation through training and further education

Training and further education represent important instruments for knowledge acquisition (Ueki et al., 2011). All interviewees stressed the relevance of regular training and further education measures. Interviewee 2 finds further education to be essential due to the increasing performance spectrum from customer requests and the constant development in the sector underlining the growing challenges firms operating in the construction industry are facing (Hari et al., 2005). According to this interviewee, many skilled workers would not fulfill the requirements for 2013. The Interviewee expects his employees to show more interest in further education. He

"continually pushes the employees to motivate them towards further education." In most cases, he identified a lack of ambition. "The employees do not want to do anything related to their job after five o'clock in the afternoon, and in the mornings before their work begins they are only interested in the 'Bild newspaper' and not in the trade journals spread over the employee break room." The negative evaluation regarding employee motivation stands in stark contrast to the contents of their homepage where open-minded employees are presented. For example, a video is shown where a trainee presents both the company and the trainee program. Contents of a firm homepage do not necessarily need to mirror reality, but in this case, they signalize a higher employee motivation than mentioned during the interview. Interviewee 3 is content with his employee's will to learn, even though he adds that he must sometimes show the advantages of these activities. The different businesses are managed by different master carpenters, who constantly improves their skills. "Several sections, such as the energetic consultation, undergo especially fast development, and we must consider this." Interviewee 5 confirms the necessity of further education measures. However, he has decided to no longer financially support these measures after two of his employees left the company "shortly" after completing a polishing course he had paid for. Interviewee 8 addressed the issue of training measures needed in some construction projects indicating that projects are often not comparable but call for specific knowledge (Ribeiro and Ferreira, 2010). Addressing the competitive pressure, interviewee 10 highlighted the need for a constant development in order to avoid "running far behind". Nevertheless, at the same time he also mentioned the missing time, which precludes the idea of having regular internal training.

Additionally learning by doing is considered as a nearly automatic given. Statements, such as that each individual grows with their tasks dominate among the interviewees. In special cases, the trainees receive tasks that lie above their professional level (Interviewee 4). This should train them in the ability to find a solution. This presumes, however, that the respective foreman does not operated at full capacity so that he can intervene if necessary. Interviewee 8 mentioned that one employee is "just thrown in at the deep end and has to get on with it". The informant hopes that this proceeding allows the employee to be able to solve problems on his own. These statements are in line with Fong and Choi´s (2009) findings. Interviewee 9 stressed the importance of observations with regard knowledge creation and stated that during vocational training the employees simply "run along" (Nonaka, 1994). Once the vocational training is terminated smaller projects are transferred to the employees concerned. Interviewee 10 talked about similar proceedings.

4.3 Knowledge sharing

Knowledge sharing is another crucial process as it gives individuals the opportunity to create new knowledge through the combination with existing knowledge (Amalia and Nugroho, 2011). The findings indicated that the current state of knowledge sharing is perceived as satisfactory. Most interviewees observed partial, but clear, improvements in comparison to what they had in the past. Interviewee 2 mentioned that the willingness to share knowledge is pronounced more strongly with some foremen than others. The interviewee's efforts still contribute towards an improvement of the

knowledge sharing. Interviewees 3 and 10 emphasized that much convincing was needed and the employees needed recurring reminders. Interviewee 3 mentioned the "exchange between old and young". Older employees were more willing to share their handiwork abilities with others as they realized that this could help balance out the purely theoretical (new) knowledge of the younger generation. Additionally, Interviewee 3 mentioned the disadvantage of "having that what is taken for granted being passed on", which all employees already mastered, e.g. screwing a screw into a piece of wood.

Interviewee 10 stated that knowledge sharing has long been a problem in the firm as an older journeyman was of the opinion that the younger ones had to acquire the relevant knowledge independently. Because of a longer (perennial**)** process, the interviewee succeeded in changing the journeyman´s mind who is now willing to share his knowledge and expertise. Incentives for the transfer of knowledge are given more indirectly, e.g. a foreman is praised if their trainee "develops well" (Interviewee 5). The findings nicely illustrate the efforts needed to motivate to knowledge sharing (Egbu et al., 2005).

5 Discussion and conclusion

This paper examined knowledge creation in German SMEs operating in the construction industry. Given the meaning of knowledge creation in innovation on the one hand (Du Plessis, 2007) and the lack of knowledge creation studies on the other hand (Mitchell and Boyle, 2010), our understanding of the topic would benefit from more research. The present study's intention was to contribute to the knowledge creation literature with regard to SMEs.

The findings indicate that knowledge creation is a process involving a number of external partners. This suggests that SMEs owners are obviously aware that to foster knowledge creation and therefore organizational development they need to involve various types of knowledge (Sammarra and Biggiero, 2008). The involvement of external sources also helps smaller firms to better deal with resource constraints (Egbu et al., 2005). Additionally, the findings clarify the various objectives these networking activities can fulfill in SMEs (cf. Fuller-Love and Thomas, 2004; Gilmore et al., 2001), i.e. problem-solving, access to new information etc. The sample firms in this study are making use of knowledge sources such as customers, suppliers, business partners, associations and befriended companies. It became clear that the interviewees give priority to informed external knowledge sources such as befriended companies from the same trade. The emphasis is on the exchange of technical knowledge; therefore leaving out the potential for improvement and development in other business areas and/or other types of innovation. For example, one would assume that customers can offer a contribution towards the product-specific knowledge creation during the supply creation process (i.e. production) as well. As regards different types of innovations, other external knowledge sources such as universities and research organization would contribute to more advanced products/innovations (Tödtling et al., 2009).

The findings also underline the importance of geographic proximity with regard to

knowledge creation; the majority of external partners involved are in the direct proximity of the organizations making possible face-to-face communication and meeting at short notice. This situation might be explained by the nature of the industry's area of activity, which is normally regional/local. So based on the findings one can conclude that proximity is not only relevant to start-ups (e.g. Presutti et al., 2011) or established technology-based firms working in clusters (e.g. Gilbert et al., 2008). Not surprisingly, the findings stress the role of the managing directors as initiators of knowledge creation (Culkin and Smith, 2000; Lowik et al., 2012). The managing directors of the sample firms are not only interested in external knowledge creation but in internal knowledge creation as well. Even though the latter process is time consuming and requires hard work in order to convince their staff of the usefulness of activities related to knowledge creation. Closely related to knowledge creation are the aspects of learning and further training. The informants are concerned with a constant development of the organizations´ human capital. This may reflect Germany´s tradition of vocational training and further education. It also underlines the role of knowledge in the construction industry as a means to competitiveness. With regard to the application of IT, the informants appear to be reluctant underlining previous research (Yun et al., 2011). Instead, activities relating to knowledge creation are mainly face-to-face-based.

From a theoretical point of view, the findings provide some fresh insights into how smaller firms deal with the issue of knowledge creation. These insights are important as continuous knowledge creation activities are considered as relevant to survival and innovation. Additionally, the findings provide a better understanding of knowledge creation activities in SMEs operating in the construction industry.

From a practical point of view, this study points out the need for firms to engage in activities related to knowledge creation to ensure the firm´s well-being. The findings clarify that knowledge creation is an issue that concerns firms operating in traditional industries as well. The study demonstrates that the inclusion of different external sources can be a very cost-effective way of getting access to valuable sources of information and knowledge and therefore a means to organizational development and innovation. This approach can be used as a model for other SMEs operating in the construction sector. Even though the sample firms make use of several external sources of knowledge creation, they seem to have reservations when it comes to the inclusion of academia as embodied by universities and other research institutions. This clarifies that the latter needs to rethink their approach when trying to positioning themselves as a further source of knowledge creation. As many universities and research institutions emphasis their role for regional development and given the sector´s impact with regard to regional employment, an instigation of appropriate activities are welcome.

The authors are aware that the presented study has several limitations. Firstly, the results were gained from a relatively small number of SMEs; therefore, the reliability of our findings is limited. As outlined in the literature review, empirical studies on the topic are rather rare, that is why this research is explorative in nature. Nevertheless, future studies should focus on a larger number of firms. Secondly, researchers should also consider alternative research approaches and research techniques as a way to enhance our understanding of knowledge creation. As knowledge creation results

from long-term processes, there is a need for longitudinal studies. Thirdly, future research could also expand the scope of the research by involving other aspects related to knowledge creation, for instance, the evaluation of knowledge creation activities. Finally, the emphasis on this particular country may have introduced another limitation, rendering the findings at least partly unsuitable for application in other countries. Yet, this gives us the opportunity to establish an understanding of knowledge creation in small firms in different parts of the world.

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Influences on frequency of preparation of financial statements among SMEs

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Abstract. This paper examines factors that impact the frequency of financial statement preparation among a sample of 312 SMEs. Specifically, the study examines the relationship between how often financial statements are prepared and (1) whether the financial statements are used to make decisions and (2) owners' confidence in the reliability of their financial statements. Financial statements provide important information that should be used to help guide decisions. The findings showed that the frequency of financial statement preparation was directly associated with whether the financial statements were used to make decisions and inversely associated with owners' confidence in the reliability of their financial statements. Additionally, the results showed that the frequency of financial statement preparation was directly associated with gender and size of community in which the firm was located. The results should be useful for owners of SMEs and providers of services to SMEs to better understand which factors affect how often financial statements are prepared and to provide business development assistance.

Keywords. financing, financial statements, decision-making.

1 Introduction

Financial statements allow stakeholders to use available financial information to gain a better understanding of and manage their firm. Although the use of financial statements can help stakeholders and owners make better decisions, owners of small firms often are poorly equipped to use financial statements effectively. In this case, even reliable and timely financial statements are insufficient, if owners do not know how to interpret and use them. More current and accurate information should enable owners to make better informed decisions. Owners using their financial decision must have confidence in their reliability (Van Auken, 2005).

The use of financial statements is closely linked to and supportive of the firm's strategic goals, because decisions made without regard to their financial impact can lead to a confused company focus and financial distress (Horngren et al., 2009). The importance of poor decisions, many of which are directly associated with financial management, is evident from the high discontinuance/failure rate among small firms (van Praag, 2003). Owners of small firms often lack strong finance skills and may not fully understand the impact of their decisions. Bad decisions often create extensive

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operational problems and threaten their firm's viability (Timmons and Spinelli, 2004). Instead, firms should use financial statement information to evaluate the impact of their decisions (Breen et al., 2004) and manage their business operations efficiently and effectively (Shields, 2010). Effective use of current financial statements is especially important considering that poor financial management is a leading cause of financial stress and business failure (Carter and Van Auken, 2005; Coleman, 2002; Headd, 2003; Wiklund and Shepherd, 2005).

Interpretations of financial statement information can be influenced by owners' perceptions of their firms' potential. Accurate and timely information is required, but effective usage also requires valid assessment of the financial statements. Entrepreneurs generally are optimistic about their firm's financial potential, which can lead to inaccurate analysis, interpretations, and assessments of their firm's potential and impact of decisions in a way that can increase the financial distress and the probability of failure (Landier and Thesmar, 2009; Smith, 2011). While external assistance with interpreting financial statements might help owners make better and more informed decisions (Breen et al., 2004), Gooderham et al. (2004) reported that owners of small firms tend not to seek external financial advice.

This paper investigates the factors that are associated with the frequency of financial statement preparation by owners of SMEs. Specifically, the paper examines the association between the frequency of financial statement preparation and whether the financial statements are used to make decisions as well as the extent that owners believe their financial statements are reliable. Both issues are critical, especially considering that financial statements affect all stakeholders, yet most research on financial statements and their use has focused on large firms, with few examples of studies of how SMEs use financial statements in making decisions (Shields, 2010). The important information in financial statements must be incorporated into any firm's operational and strategic decision-making processes though, because ignoring or misusing that information can harm all areas of the firm: unreliable operations, ineffective marketing, and an inability to hire qualified personnel (McMahon, 2001; Timmons and Spinelli, 2004). More frequent preparation provides the opportunity for owners to have access to more current information from which to base their decisions.

2 Research issues

The background of the entrepreneur and firm characteristics are key determinants of decision making tactics (Avery et al., 1998; Chaganti at al., 1996; Watson 2002). For example, business owners who don't have good financial information about the likely impact of their decisions on their firms may make choices that create risk and reduce potential returns (Van Auken, 2001). Romano and Ratatunga (1994) and Romano, Tanwwski and Smyrnios (2001) recognized that decision making in small firms is complex and involves many factors, whereas Busenitz and Barney (1997) noted that limited experience and overconfidence often leads to inappropriate decisions, in which case small firms are particularly vulnerable to the impact of poor financial decisions because of their limited resources. The informational value of financial statements provides the basis for many of the firm's decisions. Sian and Roberts

(2009) reported that owners' understanding of financial statements varies widely, such that many owners are confused by the information. The complexity of the statements makes them less useful to SME owners, who instead rely on their accountants to explain the information to them.

2.1 Owner's use of financial statements to make decisions

Several papers report that owners want better information and the quality of information they obtain determines the effectiveness of their decisions (Berger and Udell, 1998; Bruns and McKinnon, 1993). Traditional finance theory assumes rational decision making, but behavioral finance also acknowledges the potential influence of overconfidence and optimism on decisions (Barberis and Thaler, 2002; Ritter, 2003). A lack of financial skills can signal a need for owner training on how to use financial statements (Berger and Udell, 1998; Cassar and Ittner, 2008). However, owners with a stronger finance and accounting background are more likely to use external accounts for advice because they understand the importance of accurate statements (Cassar, 2009; Sian and Roberts, 2009).

Holmes and Nichols (1988) also note that the use of annual financial statements is associated with firm characteristics and demographics. For example, the frequency of financial statement preparation varies with the use of outside funding and venture size (Cassar, 2009). Small firms may also tend to be less financially sophisticated (McMahon, 2001; McMahon and Stanger, 1995). They rarely use financial statements when making decisions (Halabi et al., 2010).

Sales, often used as a proxy for firm size (Carter and Van Auken, 2005), may help determine the complexity of a firm's operations and financial reporting needs. Berger and Udell (1998) suggest that smaller firms are more financially opaque, but become more financially transparent as they grow. Therefore, owner use of financial statements should vary with sales. Higher sales imply higher resource needs, greater financial exposure, and the need for more financial information. Lower sales may motivate owners to devote more attention to the associated financial impact on their firm.

This reasoning leads us to predict:

H1: The frequency of financial statement preparation is directly associated with whether financial statements are used to make decisions.

2.2 Owners' confidence in their financial statements

The frequency of preparation may be an indicator of an owner's confidence in the reliability of their financial statements. Firms that have financial statements prepared more often likely are more sophisticated and have a greater understanding of their importance for decision making (Cassar, 2008, 2009). The reduction of uncertainty, especially in competitive environments, is directly associated with the frequency of financial statement preparations. Small firms that have their financial statements prepared less frequently may not perceive a benefit from the reports. These firms likely fail to recognize the benefits of more timely financial information, are not willing to incur higher costs, and feel less comfortable in using the information they

would obtain. Owners may believe that unreliable financial statements are not a good use of the firm's time or resources.

Confidence in the reliability of financial statements may be affected by various factors. For example, whether firms have employees who are sufficiently knowledgeable about financial statements may impact the nature of interaction and explanations between the owner and the hired expert (Smallbone et al., 1993), which in turn may make owners more comfortable with the use of financial statements. Level of revenue, which can serve as a proxy for firm size and, perhaps, sophistication can be associated with use of financial statements. Changing levels of revenue also alter the firm's perspective on its resource constraints and needs (Byers et al., 1997). Neeley and Van Auken (2010) confirm that the level of revenue affects small firms' decisions, and Busenitz and Barney (1997) suggest that organizational size affects decisions, in that larger firms have more resources and information on which to base their decisions. In turn, accurate and current financial statements are critical to understanding how revenue levels affect small firms, because they must plan for associated resource demands. These effects, in combination, lead to the following hypotheses:

H2: The frequency of financial statement preparation is inversely associated with the owner's belief in the reliability of the financial statement.

3 Methodology

3.1 Sample and questionnaire

The questionnaire was developed during the fall of 2010. In addition to findings from focus group discussions, questionnaire development was based on prior research into small firm financing decisions, including Van Auken (2005), Carter and Van Auken (2005), Busenitz et al. (2003), Kuratko, Hornsby, and Naffiziger (1997), McMahon and Stanger (1995), Petty and Bygrave (1993), and Ang (1992). After pretests and further revisions, the final questionnaire comprised two sections: (1) demographic information and (2) information associated with the use and understanding of financial statements. The first section asked respondents about the characteristics of their firms, including its age, organizational structure, type, total assets, and revenue and the gender of the owner. The second section focused on their use of financial statements, including the frequency of financial statement preparation, confidence in the accuracy of the financial statements, confidence in ability to interpret their financial statements, and whether the financial statements were used when making decisions.

The sample consisted of small firms located in a southwestern US state and was designed to represent the structure of the region, following stratified sampling principles in finite populations. The southern tier of the state was initially segmented into districts. The population of firms included all SMEs located in these districts, and then the owners of ten small firms within each district were contacted to ask for their participation in the study. If the business owner declined, another business from the district was contacted. Nonresponse bias thus should not be an issue, because

non-responding organizations were replaced by similar organizations. The sizes and ages of the final sample did not differ from the original sample at the .01 level.

Owners served as the respondents for this study because of their importance as decision makers, and because their perceptions shape strategic behavior (O'Regan and Sims, 2008; Van Gils, 2005). A total of 312 useable questionnaires were obtained. Geographic specificity offered several advantages. First, it facilitated our data collection—a benefit that is especially relevant in the context of the regional differences that might exist among owners of small firms. Second, using data from a single state minimizes the number of extraneous variables. For example, various states have different educational programs, different levels of support for small firms, and variations in banking practices associated with financial statement requirements (Carter and Van Auken, 2005).

3.2 Variables

Dependent variable. The dependent variable measured owners' frequency of financial statement preparation. Respondents indicated how often their income statement, balance sheet, and cash budget were prepared (1 = never, 2 = monthly, 3 = quarterly, 4 = annually). These responses were gathered into a new variable, "frequency," that included the very highly correlated frequencies of preparation of the four financial statements..

Independent variables. The first independent variable in the regression analysis pertained to whether the owner used financial statements when making decisions. The variable took a value of 1 if financial statements were used in decision making and 0 if not.

The second independent variable, called "reliability" was constructed from two questions that had highly correlated responses. Owners were asked about their comfort in their ability to use financial statements to make decisions. The variable was calculated at the (arithmetic) mean value of owners' ranking (1–7 scale, 1 = not comfortable, 7 = very comfortable) of their ability to interpret an income statement, balance sheet, cash budget, expense forecast, and sales forecast. These five variables were combined into a single variable, because respondents' rankings were highly correlated. The second variable used to construct the "reliability" variable was owners' confidence in the accuracy of their financial statements (1-7 Likert Scales, 1=confident and 7=not confident).

Control variables. The two control variables used in the study were gender and size of community in which the firm operated. Both control variables were found to be associated with financial management issues in previous studies.

Gender. A number of studies (Carter et al., 2003; Chaganti, et al 1995; Coleman and Robb 2009; Neeley and Van Auken, 2010; Van Auken, 2005) indicated gender differences relative to a variety of small firm financial issues. Women are more risk averse than men (Borghans et al, 2009). Other studies found that women approach entrepreneurship differently than males, including risk tolerance and management of risk, and demonstrate less confidence in entrepreneurship than males (Kirkwood, 2009; Langowitz and Minniti, 2007). These issues may lead to gender differences in issues associated with financial management.

Community size. Van Auken (2005) found that firms located in smaller sized communities may be less sophisticated and informed than firms in larger communities. Glaeser (2007) reported that location impact entrepreneurship in several ways. Several authors (Figueredo et al., 2002; Henderson, 2002) emphasized the role of entrepreneurship relative to location, but also emphasized the disadvantages of small many firms that are located in remote locations.

4 Analysis

The results were initially summarized using univariate statistics to identify respondent characteristics. Percentages for categories were calculated for the educational level of the owner, gender, type of business, total assets, and revenue.

The Spearman correlations (Table 2) between the independent variables assessed the significance of the relationships between the control and independent variables. The Spearman correlations coefficient estimation is a non-parametric technique based on ranks rather than the value of responses. We used this non-parametric technique because of our uncertainty about the population distribution. Because no significant correlations appeared among the independent variables, multicollinearity was not a problem.

Table 1. Spearman correlations between variables (n = 312)

Variables	Gender	Community Size	Used to Make Decisions	Reliability
Gender	1.0			
Community size	0.107	1.0		
Used to make decisions	-0.020	-0.083	1.0	
Reliability	-0.093	-0.0210	-0.277	1.0

Regression analysis is commonly used in entrepreneurship research, because it appears to be the most suitable method for understanding the relationship between dependent and independent variables. It is especially relevant for analyzing how the dependent variable changes as the independent variable shifts. We thus used two regression models: a generalized least squares model when owners' comfort in using financial statements was the dependent variable and a logit regression model when the owner's actual use of financial statements was the dependent variable.

Generalized least squares analysis examined the relationship between the frequency of financial statement preparation (dependent variable; never, monthly, quarterly, yearly) 1–7 Likert scale ranking) and gender, size of community (<5000, 5001 – 10,000, 10,001-25,000, 25,001 – 50000 and >50,000) , whether financial statements are used to make decisions (yes/no), and reliability of use (confidence in accuracy of financial statements (1-7 Likert Scale, 1= very confident and 7= not confident) + comfort in ability to interpret financial statements (1-7 Likert Scale, 1= very comfortable and 7=not comfortable).

The regression model was follows:

FSP = $a_0 + b_1$Gender + b_2CS + b_3Used + b_4Rel

where:

FSP = frequency of financial statement preparations
Gender = gender of respondent
Used = whether financial statements were used to make decisions
Rel = owner comfort in using financial statements + owner comfort in interpreting financial statements

5 Results

5.1 Sample characteristics

Table 2 shows the percentage of respondents by category. Less than one-half of the respondents' highest educational level was high school. Just over half of the respondents had a bachelors or graduate degree. About two-thirds of the business owners were male. Almost one-half of the firms were organized as sole proprietorships, followed by corporations (17.1%) and partnerships (16.8%). About 37.9% of respondents were retail and about 42.1% were service firms. Approximately 33.6% of responding firms had total assets greater than $100,000. The distribution of other firms among the various size categories was similar. The total revenue of about 39.1% was greater than $100,000, and the distribution of firms among the various other categories was similar.

Table 2. Characteristics of responding firms (n = 312)

Educational level	**Percent**
High school	43.4
Bachelors degree	35.7
Graduate degree	16.1
Other	4.8
Gender	
Female	34.6
Male	65.4
Legal structure	
Sole proprietorship	49.3
Partnership	16.8
S-Corp	7.1
Corporation	17.1
LLC	9.6
Type of business	
Retail	37.9
Services	42.1

Agricultural	5.1
Manufacturing	6.8
Other	6.8
Total assets	
< $10,001	17.7
$10,001-$25,000	10.5
25,001-50,000	11.2
50,001-75,000	14.8
75,001-100,000	11.2
$100,000	33.6
Revenue	
< $10,001	15.9
$10,001-$50,000	26.5
$$50,000-$100,000	18.2
>$100,000	39.1

5.2 Regression analysis

The regression results in Table 3 (F = 10.65, significant at 1%; R2 = 25.11) show the association between frequency of financial statement preparation and (1) gender, (2) community size, (3) whether financial statements are used in decision-making and (4) respondent assessment of their financial statement reliability. The coefficient for whether financial statements are used to make decisions (coefficient=1.009, significant at 1%) is directly associated with the frequency of financial statement preparation. The more frequently financial statements are used to make decisions, the more frequently the financial statements are prepared. Conversely, the less frequently financial statements are used to make decisions, the less frequently the financial statements are prepared. This finding provides support for H1 – frequency of financial statement preparation is directly associated with whether financial statements are used to make decisions.

Table 3. Least squares regression analysis with frequency of financial statement preparation as dependent variable (n = 312)

Variables	**Coefficient**
Intercept	6.543 ***
Gender	- 0.770 ***
Community size	0.476 ***
Used to make decisions	1.009 ***
Reliability	- 0.772 ***
Notes: F = 10.65 *** - *** Significant at 1%	

Financial assessment of decisions is often a central issue, because of the potential

financial risk exposure. Firms that have their financial statements prepared more frequently may better understand the informational value of the financial statements than firms that have their financial statements prepared less often. Firms recognizing the informational value of financial statements probably use them when making decisions. This finding reflects recognition of the value and importance of the financial statements when making decisions.

The coefficient for reliability (coefficient = -0.772, significant at 1%) is indirectly associated with the frequency of financial statement preparation. The higher the reliability ranking indicates less frequent statement preparation. The lower the reliability ranking indicates more frequent preparation of statements. This finding provides support for H2 - the frequency of financial statement preparation is directly associated with whether financial statements are used to make decisions.

Owners who are more confident in the reliability of their financial statements may have the sophistication to understand the relevance of good financial statements. Financially sophisticated owners would be expected to demand financial statements that are reliable while less sophisticated owners may not understand the importance of reliable financial statements. Financially sophisticated owners would require that their financial statements be reliable so they could use the financial information to aid decision making.

The two control variables used in the regression were gender (coefficient = -0.770, significant at 1%) and community size (coefficient = 0.476, significant = 1%). These results indicate that firms owned by females have financial statements prepared more often than firms owned by males. The results also show that size of community in which the firm is located is directly associated with frequency of financial statement preparation. Firms in larger communities have financial statements prepared more often than firms in smaller communities.

6 Discussion

Financial statements provide some of the most basic and important information when making decisions. Good financial decisions are predicated on reliable financial information and an ability to understand financial statements. Ineffective decisions can lead to poor financial management and, ultimately, distress/failure (Headd, 2003). Effective use of financial statements when making decisions can lead to improved financial management and position the firm to remain viable. Even with reliable information, being able to understand and interpret financial statements is a prerequisite for effective decision making.

Understanding what factors affect the frequency of financial statement preparation is important because of the information value of financial statements. Firm decisions have the potential to improve success or lead to failure. Financial risk, especially important to evaluate, can be evaluated using financial statements. Better financial information is possible through more current and valid financial statements, and better financial information can lead to better quality decisions.

The findings of this study provide greater insight into what factors influence how often small firm prepare financial statements. The dependent variable used in the

study was the frequency of financial statement preparation. Financial statements were selected because of their important role in the financial management of small firms (Carraher and Van Auken, forthcoming; McMahon, 2001; Timmons and Spinelli, 2004).

Two of the most important consideration affecting the frequency of financial statement preparation is whether they are used to make decisions and owners' confidence in their reliability. The finding showed that both factors were associated with the frequency of preparation. The positive association between frequency of preparation and whether the financial statements were used to make decisions suggests that owners recognized the information value of the financial statements. More frequently prepared financial statements deliver more current information that can be used to better assess risk exposure and decision consequences. Owners who have financial statements prepared less frequently apparently do not recognize the informational value contained in the financial reports and associated potential value of the information when making decisions. Of course, the frequency of financial statement preparation does not guarantee good decisions by owners (Shields, 2010; Timmons and Spinelli, 2004). The quality of their analysis of the financial information and their effective implementation are pivotal issues affecting decision quality (Carraher and Van Auken, forthcoming).

The results also show that frequency of financial statement preparation was associated with owners' believe in financial statement reliability (comfort in using/confidence in accuracy). The relationship indicated that financial statements were prepared more frequently if owner had less confidence in their reliability. This finding is consistent with Carraher and Van Auken (forthcoming), Neeley and Van Auken (2010) and Busenitz and Barney (1997) who emphasize the importance of good financial information in a timely manner. Better and more reliable information can be obtained from more current financial statements.

Owners who have financial statements prepared more frequently may be more financially sophisticated and more fully understand the informational value of good/current financial information. On-the-other-hand, owners who are not confident in their statements may simply opt to not spend time and money on having their statements prepared. Alternatively, these owners may simply not be very sophisticated and not recognize the informational value of current financial statements.

Having confidence in the reliability of financial statements and high frequency of preparation suggests that owners understand the importance of financial information. Carraher and Van Auken (forthcoming) found that confidence of financial statements was directly associated with using them to make decision. Owners may still rely on advisors to draw conclusions about the information in the financial statements while using their own judgment and analysis. On the flip side, they may be not having confidence in the reliability of their financial statements apparently limits the frequency of preparation (e.g. why have them prepared if they are not reliable) This sequence matches behavioral finance theory, in which decision makers form beliefs that influence their practice (Barberis and Thaler, 2002; Ritter, 2003).

The results also found that frequency of financial statement preparation was negatively associated with gender in that frequency of financial statement preparation

was more common among male-owned firms than female-owned firms. Gender was previously associated with small firm financial decision in studies by Neeley and Van Auken (2010), Cassar (2009), Carter et al. (2003), and Coleman (2002).

The results also showed that frequency of financial statement preparation was positively associated with community size. Financial statements were prepared more frequently by small firms located in larger communities than in smaller communities. Van Auken (2000) reported that firms in smaller communities may be more isolated and have less access to resources, and that small firms in larger communities had a better understanding of financial management issues than firms in smaller communities. Lang, Calantone and Gudmundson (1997) believe that small firms must rely on external expertise, often not available in small communities, when developing business strategies. A better understanding of financial issues would likely lead to more frequent preparation and use of financial statements. Conversely, a weaker understanding of financial issues would likely lead to less frequent preparation and use of financial statements.

7 Conclusions

This analysis of the factors associated with how often financial statements are prepared is based on a sample of 312 SMEs located in a southwestern US state. Few studies previous have examined the financial statements and their use among owners of SMEs. This article therefore is important, considering the critical role of financial statements for stakeholders and the financial impact of owners' decisions on firm sustainability.

Owners who use financial statements to make decision also have their financial statements prepared more often but have less confidence in the reliability of their financial statements. The financial statements are also prepared more frequently by women owners and by firms in smaller communities. These findings may be due to owners needing more current financial statements when making decisions, but also because owners who are not confident in their financial statements would not want to waste time with unreliable information. Training to ensure that owners understand financial statements can affect how the financial information is used in decision making. A better understanding of the informational value of financial statements will likely lead to more frequent preparation. Financial statements more likely to be prepared more frequently if the owners better understand the information value and use the financial information for making decisions as well as having confidence in the reliability of their financial statements.

The results of the study should be useful for owners of SMEs and providers of services to SMEs. Financial statements provide important information that should be used, both by external evaluators and internally, to help guide decisions. Both owners and providers of services can use the information to understand which factors affect their use of financial statements. Such an understanding of what factors have this influence may improve the process by which financial statements get incorporated into decisions.

The limitations of this study provide avenues for further research. The study could be

expanded to other areas of the world to explore differences by region, ethnicity, type of business, etc. The issue of frequency of financial statement preparation, use of financial statements and firm performance could be both interesting and useful in practice. The data was collected at a single point in time. A longitudinal study could provide further evidence regarding what other factors influence how and how often financial statements are prepared, especially factors associated with a firm's maturity as well as over the business cycle.

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Cyber-physical system design automation framework for knowledge-based engineering

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Abstract. Cyber-physical system design automation utilizing knowledge based engineering techniques with globally networked knowledge bases can improve the design process for emerging systems. Our goal is to develop a comprehensive architectural framework to improve the design process for cyber-physical systems (CPS) and implement a case study with Axiomatic Design Solutions Inc. to develop next generation toolsets utilizing knowledge-based engineering (KBE) systems adapted to multiple domains in the field of CPS design automation. The Cyber-physical System Design Automation Framework (CPSDAF) will be based on advances in CPS design theory based on current research and knowledge collected from global sources automatically via Semantic Web Services. A case study utilizing science, technology, engineering, and mathematics (STEM) students is discussed.

Keywords. Cyber-physical systems, design, automation, knowledge-based engineering, artificial intelligence.

1 Introduction

1.1 Project overview

Cyber-physical system design automation utilizing knowledge based engineering techniques with globally networked knowledge bases can improve the design process for emerging systems. Our goal is to develop a comprehensive architectural framework to improve the design process for cyber-physical systems (CPS) (Cyber-physical system virtual organization, 2013). My contribution to this goal is to provide an overall structure to the case study implementation employing Axiomatic Design Solutions Inc. to develop next generation toolsets that utilize knowledge-based engineering (KBE) systems which can adapt to multiple domains in the field of CPS design automation. The Cyber-physical System Design Automation Framework (CPSDAF) will be based on advances in CPS design theory based on current research and knowledge collected from global sources automatically via Semantic Web Services. The team plans to utilize university resources and consultant services to develop a KBE environment utilizing next generation toolsets developed specifically for CPS design automation. The team proposes to further develop, implement, test, and expand the Artificial Intelligence Design Framework (AIDF) for Optical Backplane Engineering funded in part by a NASA Fellowship Training Grant (2004-2006). This dissertation was later published as a book by VDM Verlag in 2008 called Architecting Automated Design Systems. In 2013, the team plans to begin expanding the AIDF and

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develop the next generation architectural framework for CPS design automation (CPSDAF) utilizing a research testbed, STEM students, CPS portal, and case study implementation. This research will provide guidance on KBE system development suitable for multiple domains. CPS design automation will be accomplished by systematically incorporating advances in CPS design theory while developing next generation design automation toolsets with Axiomatic Design, Inc. The CPSDAF will improve on the AIDF by also providing KBE capability to address any type of CPS system for advanced design automation with modules adapted to the particular CPS domain. Based on this approach, the team plans to (1) expand the AIDF into a comprehensive framework for CPS design automation called the CPSDAF (2) utilize university resources to build a validated and verified KBE system configured by the CPSDAF for a particular CPS domain as proof of concept (3) develop next generation toolsets with Axiomatic Design Solutions, Inc. based on the results of the CPSDAF research and KBE testbed, and (4) educate next generation CPS students via STEM initiatives through CPS related university student chapter development managed by Society for Design and Process Society (SDPS) (www.sdpsnet.org). The independent portal development online provides the opportunity for three teams to work collaboratively and in parallel. Portal website domains have already been purchased and are ready for development (a) www.cyberphysicalsystem.com, (b) www.cyberphysicalsystem.net, and (c) www.cyberphysicalsystem.org). The KBE system will utilize advances in Semantic Web Services to acquire knowledge and apply advances made every day in the field of CPS to continuously improve its design automation capability for multiple domains in CPS. As more disciplines are impacted, more modules will be developed for these disciplines and STEM initiatives will be formed to spearhead this development. A systems engineering process model is provided showing the architectural framework focus area (Fig. 1).

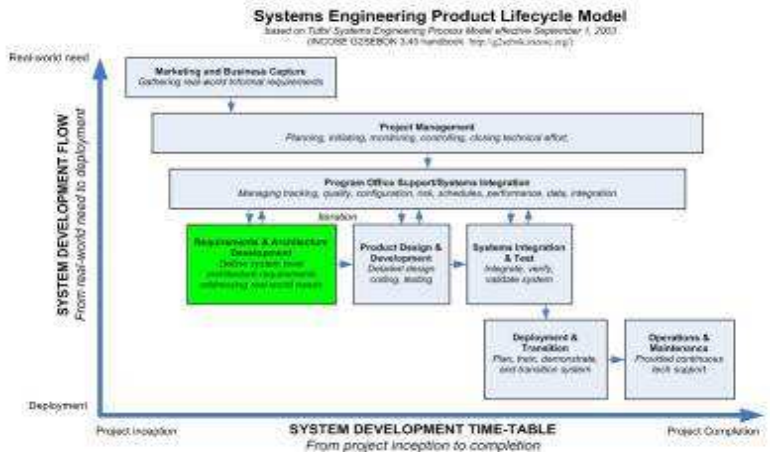

Fig. 1. Tufts' systems engineering process model (see Buede et al., 2002, p.13)

1.2 Intellectual merit overview

My team will advance research for CPS design theory and automation while developing next generation toolsets with the case study. During the exploratory

inception phase, the research team and students plan to transfer the experience gained from working on the proof of concept to develop a CPS design automation framework that can guide the implementation of multiple KBE system-of-systems (SoS) that assist in the design automation of CPS applications in various domains with networked KBE systems (Fig. 2). The designed CPS artifacts will be tested, verified, and validated to meet industry specifications.

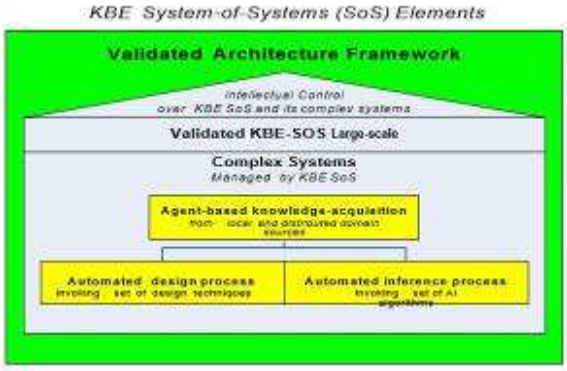

Fig. 2. System-of-systems paradigm for artificial intelligence design support.

1.3 Broad impact overview

Any university and corporation intending to improve their design process will benefit from the next generation tools developed for CPS design automation with modular expansion capability depending on domain. The KBE system will be capable of detecting and collecting advances in CPS design principles and technology by automatically securing knowledge from global sources and experts that advance the field on a daily basis. Axiomatic Design Solutions Inc. will improve on next generation toolsets based on CPSDAF research advances. STEM initiatives will be managed in the CPS portal to develop student chapters that network students together across universities to collaborate in the CPS field and develop the modules for the CPSDAF. Additional capability may be provided with a KBE system-of-systems (SoS) application that can manage networked results of KBE systems. Software engineering of the KBE SoS can be improved with expanded modules utilizing CPSDAF guidance. The CPSDAF will generate advanced KBE SoS for CPS design automation like the AIDF (Fig. 3).

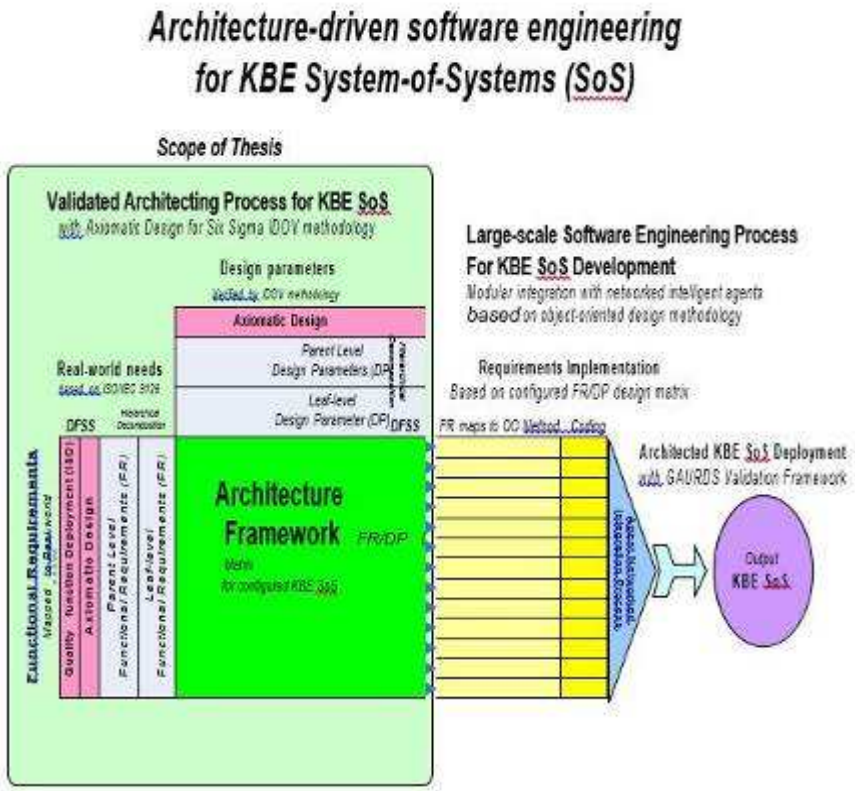

Fig. 3. Architecture-driven software engineering for KBE SoS.

1.4 AIDF expansion to CPSDAF

The Cyber-physical System Design Automation Framework (CPSDAF) will expand on existing embedded system design theory, develop next generation toolsets for CPS with Axiomatic Design Solutions, enable production of novel KBE systems adapted to CPS design automation in various domains by modular expansion, and establish SDPS student chapters to manage CPS student collaboration in STEM portals. These modules will be developed by the students working in teams and displayed in the following portals already purchased for development: (a) www.cyberphysicalsystem.com, (b) www.cyberphysicalsystem.net, and (c) www.cyberphysicalsystem.org. The CPSDAF builds on the experience gained from the NASA Fellowship and years of incremental improvement to the AIDF, culminating to this grant proposal on CPS design automation with student chapter collaboration on CPS modules. Several student chapters have already been established in various universities and will now start the CPS portal development phase.

1.5 CPSDAF guides modular development of KBE systems in multiple CPS domains

The current approach expands on the architectural framework dissertation by combining the university resources with Axiomatic Design Solutions to implement the case study for CPS design automation in multiple domains while developing next generation toolsets and KBE system adapted to CPS product engineering. This proposal expands and implements the CPS version of the architectural framework (AIDF) for design automation utilizing modular, reconfigurable, and scalable KBE systems (Fig 4). Research detail is available in the book Architecting Automated Design Systems published in 2008 (Tanik, 2008) based on the dissertation delivered to NASA (Marshall Space Flight Center) by U. John Tanik in 2006 (Tanik, 2006). The main objective of the dissertation was to produce a comprehensive framework for design automation by proposing the Artificial Intelligence Design Framework (AIDF) for optical backplane engineering case study. Similar to its predecessor architectural framework (AIDF), the CPSDAF provides a comprehensive, modular, reconfigurable, and scalable approach to develop networked knowledge-based engineering (KBE) systems that support the automated design of cyber physical systems of all types in multiple domains. The adapted KBE system for a CPS domain is expected to provide guidance to CPS designers based on automated engineering principles, artificial intelligence recommendations, general design theory, case-based reasoning methods, and other domain knowledge updated online from globally distributed sources.

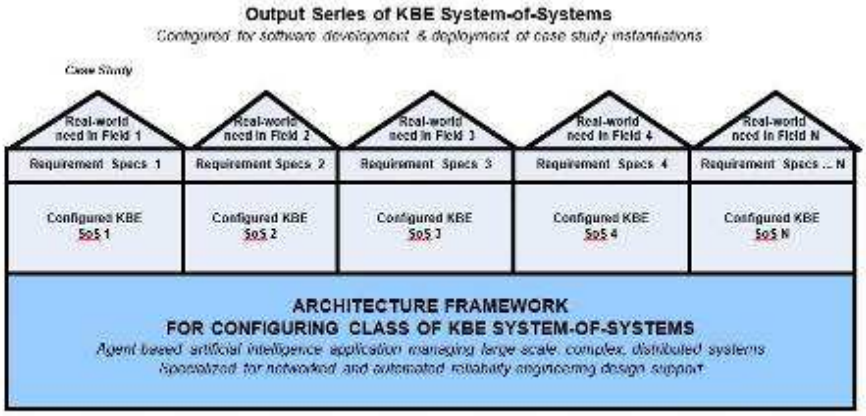

Fig. 4. Architecture-driven software engineering for KBE SoS.

1.6 CPS field driving need to manage emergent system behavior and mitigate risk

Building a system faster, better, and cheaper has been the hallmark of engineering and historically KBE systems were developed with this goal in mind. Now the challenge is identifying the best CPS design theory and principles and applying them uniformly with next generation technology. Advances in embedded system and system of systems (SoS) design are paving the way for the CPS field to profoundly impact the

economies of nations (CPS Steering Group, 2012). These new challenges require a method to capitalize on advances while building on established engineering principles without losing sight of verification and validation needs for new CPS designs. Emergent behavior during design automation could be anticipated with proper design automation techniques in place to mitigate risk. This type of approach provides a platform to structure the large-scale software engineering development process for assuring risk mitigation during automated reliability engineering (Trevino, 2005). Further compounding the issue of increasing and interdependent functional and nonfunctional quality requirements is the strict restrictions imposed by CPS concerns, such as timing concerns for component reliability (UC Berkeley, 2013). An integrated approach to multi-disciplinary system design with vast amount of knowledge is needed providing reliable design guidance with optimized design recommendations with maximum automation to improve quality, save time, and money. Factors impacting both the cyber and physical world simultaneously are now paramount to trustworthy CPS design automation (UC Berkeley, 2013). While cyber-physical systems present many new design challenges, especially for synchronously timed systems that need to interoperate seamlessly. Any timing issue with a particular set of interfacing components may cause serious cascading problems or even system failure in CPS artifacts that rely on precise input/output regulation. For instance, a unique property of a CPS artifact is precise integration requirements (Fallah, 2010). A critical codependence is thus presented to the system design process at all layers and phases, presenting unprecedented and challenging design concerns (Rajkumar, 2012). Hence, the design, construction, verification, and validation of cyber-physical systems pose a multitude of technical challenges that must be addressed by a cross-disciplinary community of researchers, engineers, scientists, and educators. If many of these issues can be addressed via system design automation, many problems can be more effectively addressed during the design process. Interactions among the multidisciplinary knowledge silos may generate increasing system functionality requiring more attention to V&V concerns during system integration. This process must be both comprehensive and adaptable to evolving environmental conditions, fulfilling both end-user needs and the engineering specifications with special emphasis on dependencies and processing speed for CPS design automation. There is a recognized need for an overarching architectural framework to achieve intellectual control over CPS design automation concerns producing a set of reconfigurable, modular, and scalable KBE systems that can assist in the design process for CPS product engineering.

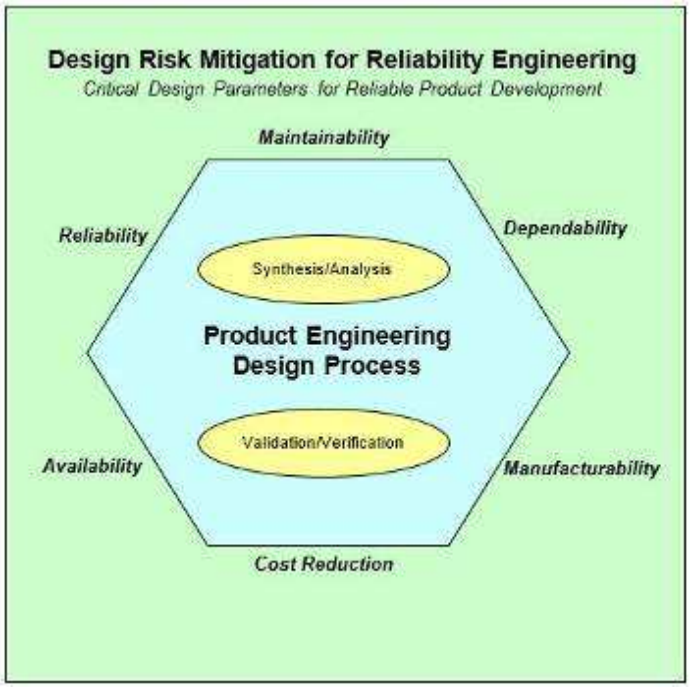

Fig. 5. Design risk mitigation for reliability engineering.

2 AIDF Research Foundation for CPSDAF

2.1 AIDF utilizing axiomatic design principles for KBE system development

The AIDF is an architectural framework to develop a set of modular, reconfigurable, and scalable systems. We discuss aspects of the AIDF as a starting point for our research expansion to develop the CPSDAF for KBE system development for CPS design automation. Knowledge-Based Engineering plays a key role in managing the vital resource of knowledge in a means that is easily accessible to decision making [13]. A centralized set of knowledge repositories are stored within a database to supply data access to the KBE system (Mylopoulos, 1996). While performing daily activities any respective worker can access the data contained within these knowledge repositories via the KBE system. Related to KBE, Artificial Intelligence capability is found in Inertial Navigation Systems (INS) (Shin, 2005) to speech recognition systems (Gevarter, 1983). On a broad-based scale there are several research ideas for utilizing Web Ontology Languages (OWL) to extend the benefits on current systems (Stoilos, 2010). The OWL makes it possible to conduct Artificial Intelligence in various applications based on an Internet standard leveraging Semantic Web advances. Logic for Artificial Intelligence traditionally carries its roots back to first order logic (Djelloul, 2009). One particular example utilizing first-order-logic can be seen in axiomatic systems which provide a set of axioms from which a large set of axioms can be combined in an effort to logically arrive at theorems and corollaries, forming design

theory (Hazewinkel, 2001). Axiomatic Design Solutions Inc. utilizes axiomatic design theory developed by MIT for product conceptual design with Acclaro Design for Six Sigma (Axiomatic Design, 2013).

2.2 AIDF requirements managed with Acclaro toolset

The requirements elicitation process for the AIDF was managed by the Acclaro Design for Six Sigma (DFSS) tool by Axiomatic Design Solutions (30). Acclaro DFSS assists in the requirements elicitation and management process for risk mitigation and design parameter identification. Features utilized in the tool to construct the architectural framework for the AIDF include the design matrix and dependency structure matrix functionality, in addition to the Quality Function Deployment (QFD) and the Failure Mode Effects Analysis (FMEA) functionality especially useful for nonfunctional requirements as well. Acclaro DFSS software implements a complete suite of DFSS tools using an axiomatic framework to reduce development risk, cost and time, by applying the axiomatic design process developed at MIT (Axiomatic Design, 2013).

2.3 AIDF configuring KBE system to accelerate design automation

A core infrastructure has been proposed and conceptualized to handle design of complex systems based on an architectural framework. The AIDF has been designed in a manner to allow the incorporation of inputs from a real time environment connected to Web Services and networked knowledge bases to be fed into the reconfigured KBE system according CPS artifact design domain. This is then utilized to choose appropriate actions for adjusting the overall design of the system at key trade-off decision points (Fig. 6) utilizing synthesis and analysis techniques that invoke any of 20 modules that contain knowledge in the form of design theory and related reasoning algorithms acquired from global expert resources. Given the continuous feedback from updated knowledge repositories, the KBE system is able to automatically provide designers immediate feedback on best CPS design tradeoffs. The AIDF provides an overall architectural framework with guidelines to manage axiomatic design theory and various applications of artificial intelligence by developing a respective KBE system for design automation. One aspect relies on knowledge gained from field experts, which is gathered and stored into a knowledge-base. An interface is provided within the system to access this input from distributed knowledge sources which supply data for processing.

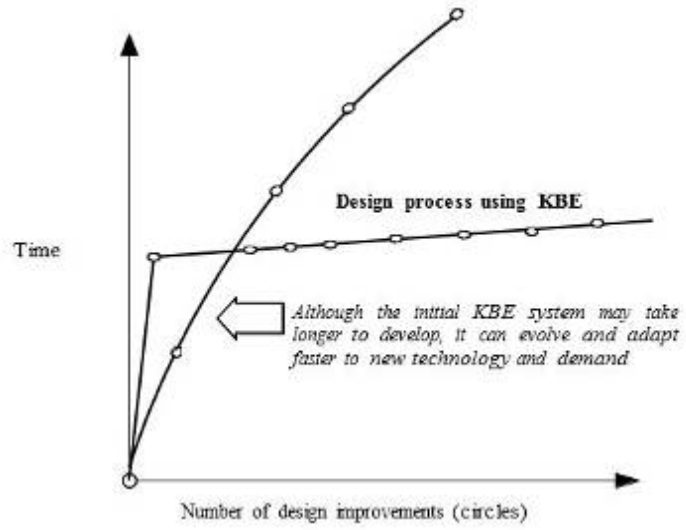

Fig. 6. KBE provides more design improvements over time.

3 CPSDAF based on AIDF to guide KBE implementation

The architectural framework will be designed to handle all types of CPS design automation concerns when building KBE systems, such as the tight integration and emergent properties, as well as codependence of the computation, physical, and network system layers. The Cyber Physical System Design Framework (CPSDAF) is based on the AIDF (Fig 1) comprised of (1) the Knowledge Assimilation Engine (KAE), (2) Knowledge Correlation Engine (KBE), and (3) Knowledge Justification Engine (KJE). As an initial step, the KAE provides a mechanism to assimilate global knowledge into the KBE system with intelligent agents gathering relevant global information that could impact the design process from Semantic Web Services. Then, the assimilated knowledge must be processed and correlated for design automation in the KCE. This design automation is accomplished by analysis and synthesis techniques based on the Common Knowledge Acquisition and Design Support (CommonKADs) standard (Schreiber, 2000). During KBE system analysis or synthesis, one or more modules are activated to work together to solve a design problem. These modules are housed in the design engine block and AI engine block of the AIDF. The NASA case study for optical backplane engineering had 20 modules in total. A set of 11 design modules are managed by the design engine block and another 9 AI modules are managed by the AI engine block (Table 3). These modules were shown to be reconfigurable and scalable. Finally, the KJE provides a mechanism to output desirable recommendations and their justifications as design rationale.

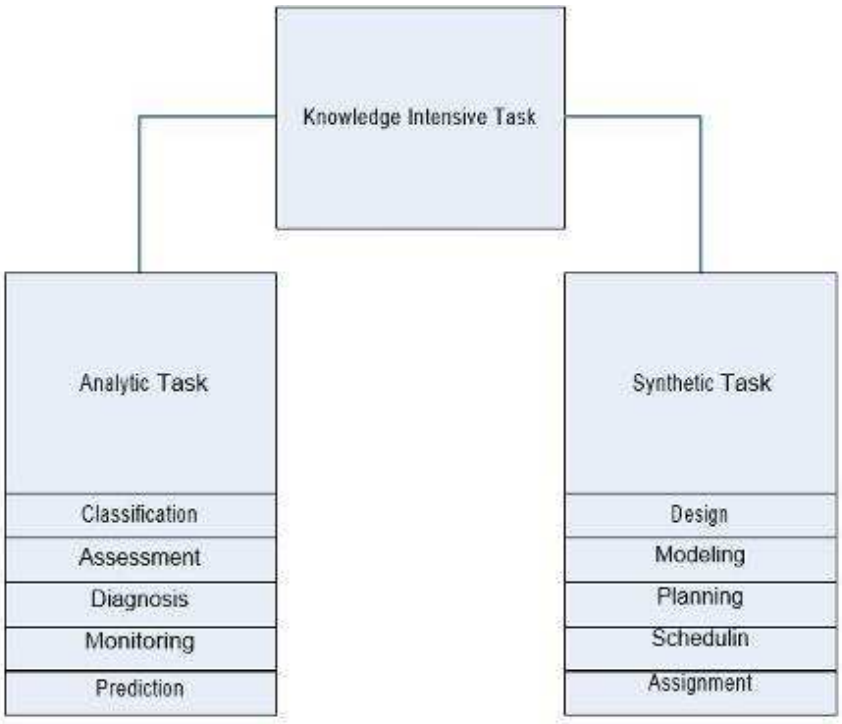

Fig. 7. CommonKADS Hierarchy of Tasks.

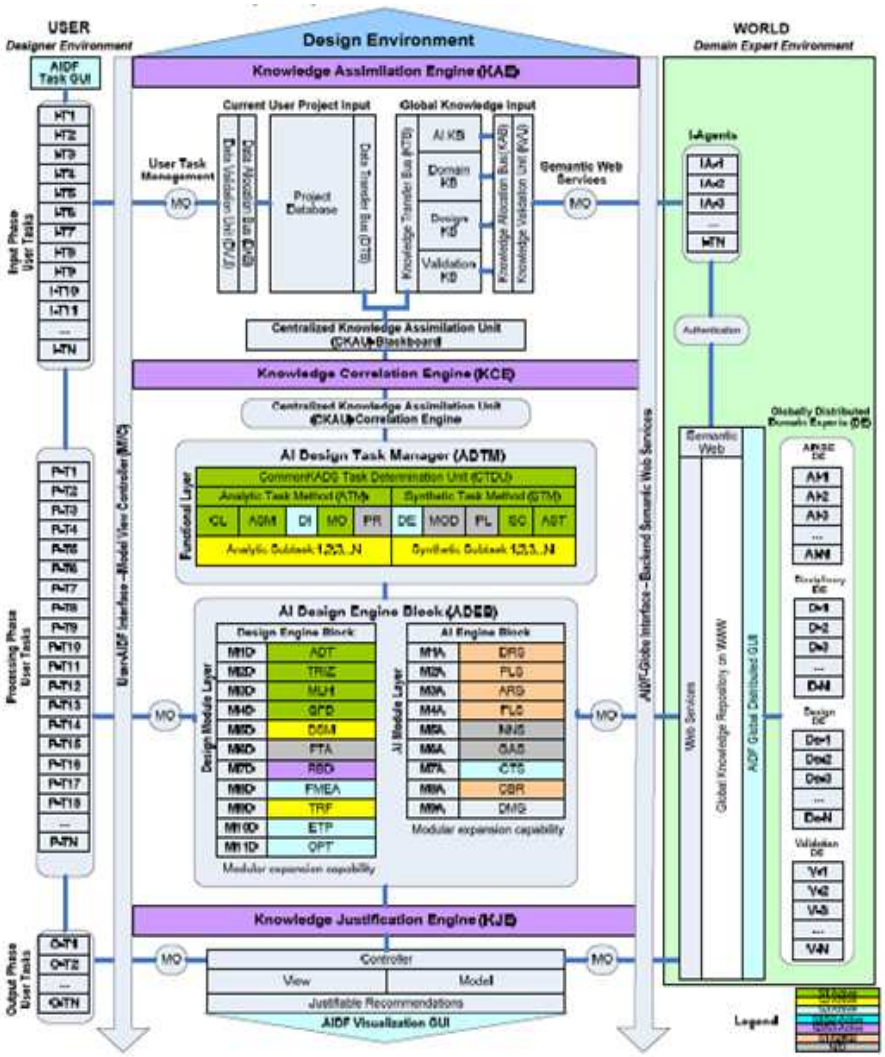

Fig. 8. AIDF architecture to be expanded with CPSDAF (Tanik and Grimes, 2005).

Table 1. AIDF Design Automation Support Modules to be expanded and scaled in CPSDAF (Tanik and Grimes, 2005).

#	**AIDF Modules**	**Mechanism provided**
M1D	Axiomatic Design Theory (ADT)	Provides an automated mechanism for hierarchical decomposition of FR and DP, provides 2 axioms, 11 corollaries, and 23 theorems for the rules base stored in the AI Engine Block
M2D	Theory of Inventive Problem Solving (TRIZ)	Provides an automated mechanism for invention, especially by searching the Semantic Web for

		appropriate DPs
M3D	Hierarchical Multi-layer Design (MLH)	Providing an automated mechanism for going from FR to DP to components, calculation of reliability and cost
M4D	Quality function deployment (QFD)	Provides an automated mechanism to ensure the customer guidelines are included in the quality of the design
M5D	Design structure matrix (DSM)	Provides an automated mechanism to determine component to component interaction
M6D	Fault Tree Analysis (FTA)	Provides an automated mechanism to predict component failures, where the calculations are based heavily on quantitative Boolean operators
M7D	Reliability Block Diagram (RBD)	Provides an automated mechanism to estimate system reliability, where the calculations are based heavily on various engineering equations, such as MTTF (Mean time to Failure)
M8D	Failure mode and effects analysis (FMEA)	Provides an automated mechanism to associate weights for each type of failure to assess fault qualitatively and trace root cause
M9D	Technology Risk Factor (TRF)	Provides an automated mechanism to assess individual component risk on a cluster, mainly by associating any given component with a multiplier that affects the DSM
M10D	Entropy (ETP)	Provides an automated mechanism to assess level of disorganization in system design during design process
M11D	Optical Backplane Engineering Domain (OPT)	Provides an automated mechanism to manipulate domain-specific knowledge for inference, specifically in field of optical backplane engineering
M1A	Domain Rule Support (DRS)	Provides an automated mechanism for domain rule support, in terms of executable rules used by the inference engine
M2A	Predicate Logic Support (PLS)	Provides an automated mechanism for logic support
M3A	Algorithmic Reasoning Support (ARS)	Provides an automated mechanism for miscellaneous algorithmic reasoning support
M4A	Fuzzy Logic Support (FLS)	Provides an automated mechanism for fuzzy logic support
M5A	Neural Network Support (NNS)	Provides an automated mechanism for neural network support

M6A	Genetic Algorithm Support (GAS)	Provides an automated mechanism for genetic algorithm support
M7A	Conant Transmission Support (CTS)	Provides an automated mechanism for component transmission support
M8A	Calibrated Bayesian Support (CBS)	Provides an automated mechanism for calibrated Bayesian support
M9A	Data Mining Support (DMS)	Provides an automated mechanism for data mining support

Table 2. Component DSM example with five components.

	C1	*C2*	*C3*	*C4*	*C5*
C1	***X***				*X*
C2		***X***	*X*	*X*	*X*
C3	*X*		***X***		*X*
C4		*X*		***X***	*X*
C5		*X*		*X*	***X***

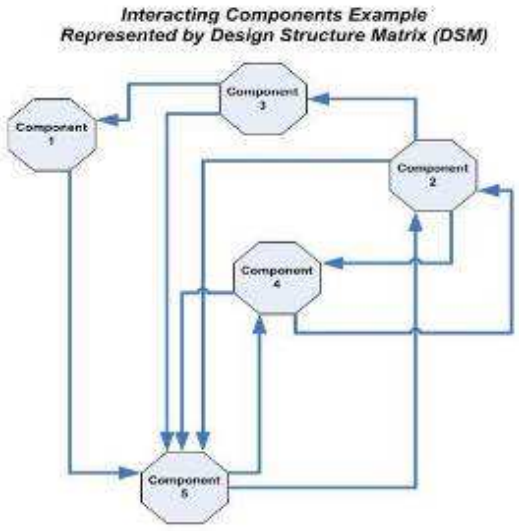

Fig. 9. Interacting component diagram that can be represented by DSM.

4 Case Study

4.1 Next generation modules, standards, and tools developed by STEM students and consulting services

The following features in the Acclaro toolset can be enhanced or expanded to meet CPS needs, e.g. Information architecture & system architecture view, design matrix, DSM, FMEA, FTA, TRIZ, PRA, and other risk mitigation and V&V techniques. These features will be further enhanced based on new research findings and theoretical innovation, in terms of synergistic design principles, methodologies, and industrial best practices to meet the needs for converging multidisciplinary engineering domains that require the tight conjoining of synchronous software and hardware concerns anticipated in cyber physical system design automation. Topics and standards found in the Software Engineering Body of Knowledge (SWEBOK) and Project Management Body of Knowledge (PMBOK), design processes such as IEEE 12207, Rational Unified Process (RUP), and agile development, will be considered in module development. Automation of key industrial standards will be provided such as software requirements specifications (SRS) with IEEE 830, software design descriptions (SDD) with IEEE 1016, and project management plan (PMP) according to IEEE 1058. The Acclaro Design for Six Sigma (DFSS) tool will be improved and many functions will be added to the tool that will support CPS design automation. Knowledge engineering functions will be automated with concept mapping technology such as Cmaptools by the Institute of Human Machine Cognition (IHMC). Various architecture views are provided, such as application architecture, information architecture, systems architecture and UML architecture. Automation of the detailed design process of software and system engineering concerns will be accomplished by applying artificial intelligence techniques to the Unified Modeling Language (UML) and the Systems Engineering Language (SysML). If a medical case study is selected as a CPS domain, then additional domain modules can be added such as the Unified Medical Language System (UMLS). An example CPS case study might be the design automation of a clinical decision support system relying on wireless technology collecting information remotely from sensors on the human body. The CPSDAF will be the framework to develop a KBE system that can automate the design process (Fig 10, 11) for such a CDSS with validation target areas (Fig. 12). Sensors have become essential components in medical systems (Dmytruk, 2007). Certain types of sensors can transform physical measurements of ambient temperature, heart rate, pulse, blood pressure, perspiration, flow rate, and acceleration into electrical signals that provide inputs to cyber-physical systems (Norton, 1989).

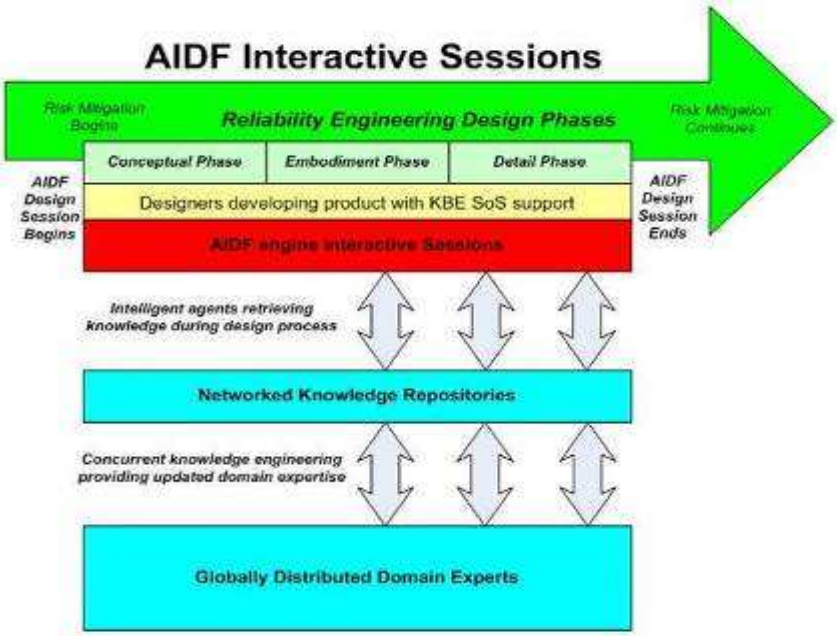

Fig. 10. Interactive AIDF sessions with KB network and agents.

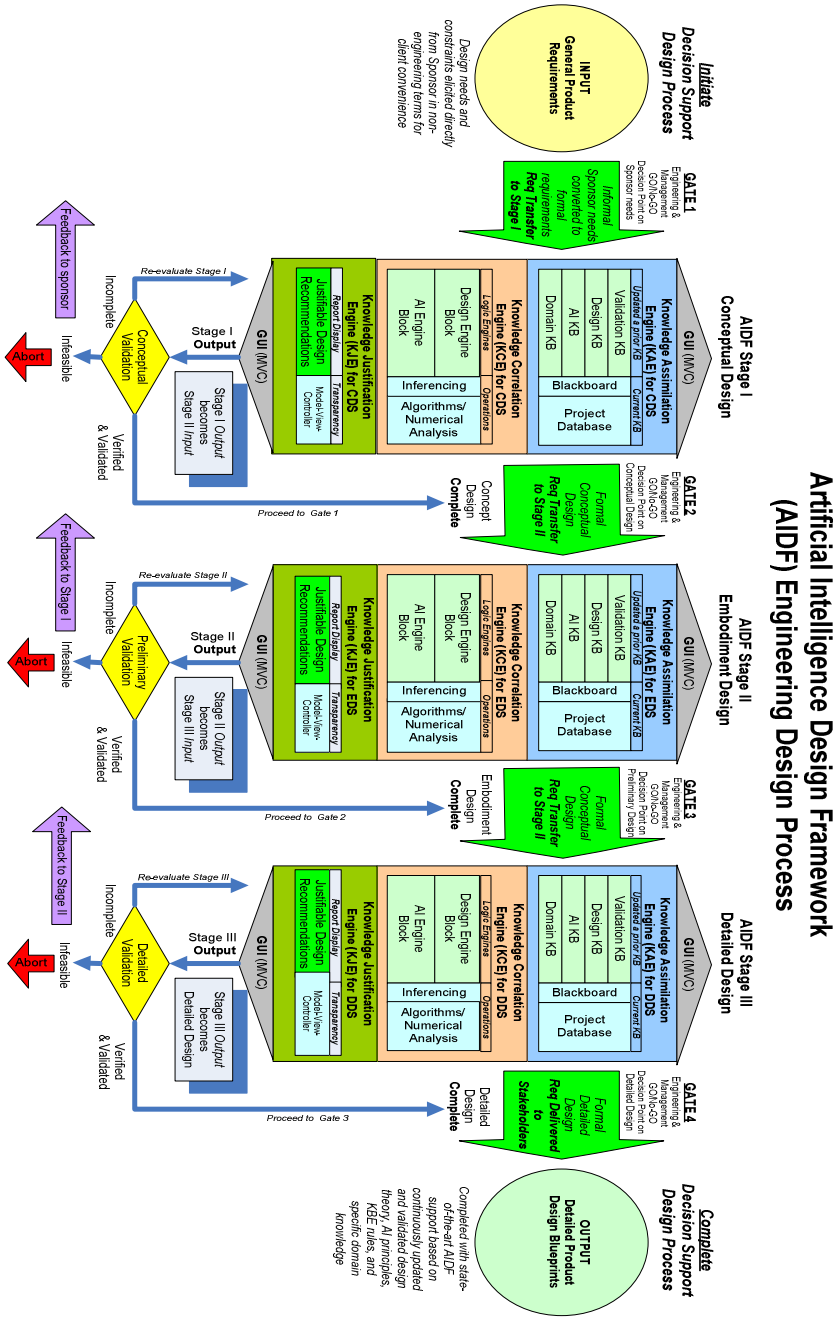

Fig. 11. AIDF Design Process Detail producing blueprints for KBE of CDSS system (Example case)

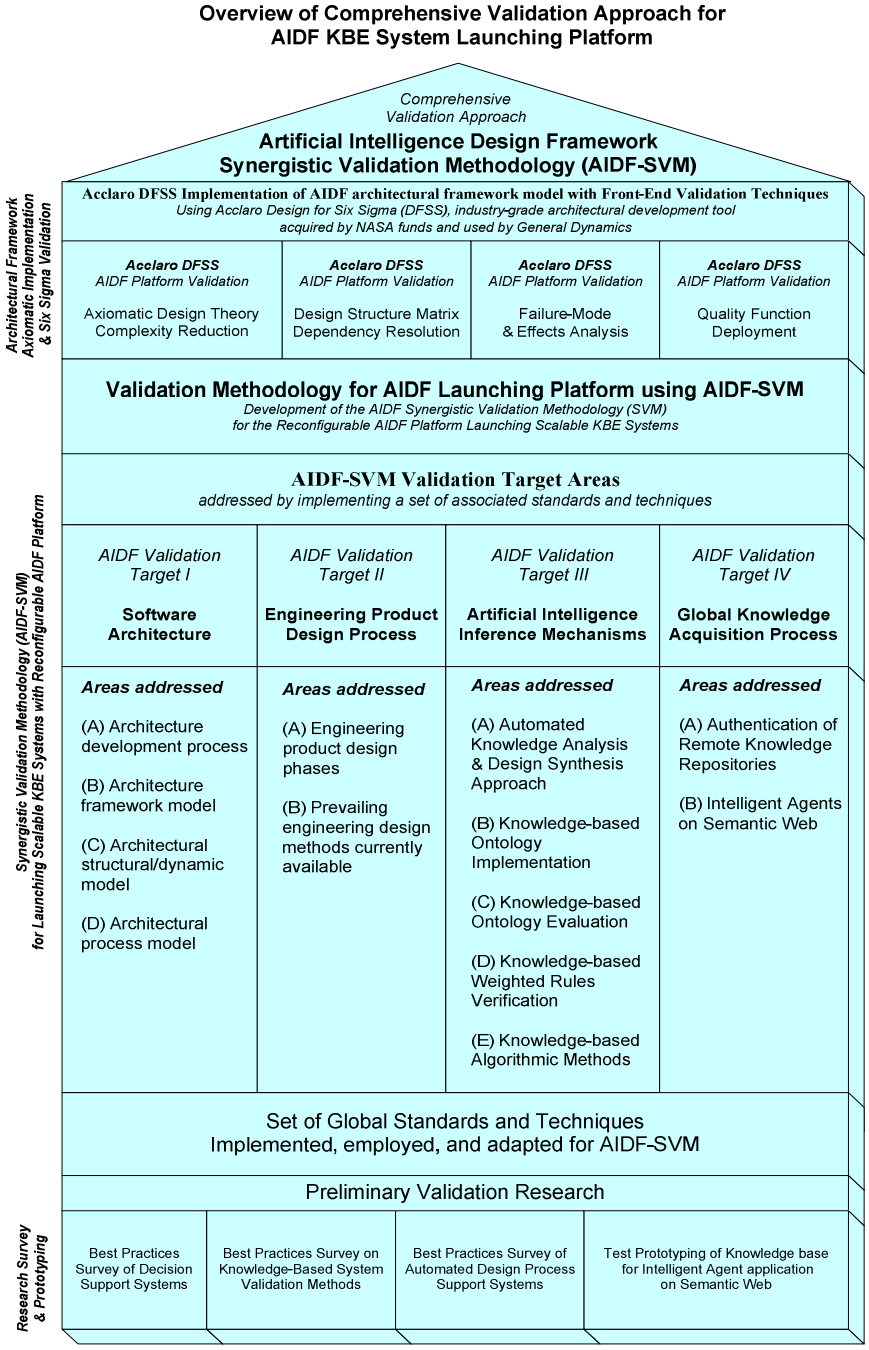

Fig. 12. Comprehensive Validation Approach for KBE SoS based on AIDF.

4.2 Reporting on CPS portal sites

We plan to report results of activity using CPS portal sites. Every semester, reporting of results will meet Specific, Measureable, Attainable, Relevant, and Time-sensitive (SMART) goals. The following
(1) Specific goal of collaboration will be achieved with a group of talented university students who would like to learn and apply their skills to the design of a cyber-physical system as a team project;
(2) Measurable goal of module research is achieved with concept mapping technology (http://cmap.ihmc.us/) and standard project management techniques using the Rational Unified Process (RUP);
(3) Attainable goal of intellectual empowerment is achieved by mentoring through the CPS portals;
(4) Relevant goal of increasing diverse computing enrollment achieved since they are in line with the U.S. agenda emphasizing the importance of teaching computing in STEM development;
(5) Time-sensitive goal of semester completion is achieved by meeting specific benchmarks as provided by the RUP and agile approach for design automation with university and K-12 students.
The SMART objectives of teamwork collaboration, modular research, intellectual empowerment, increasing diverse enrollment, and semester completion are achieved, respectively, with the objectives of:
(1) building cross-disciplinary awareness among students,
(2) engaging STEM students in highschools with experiential projects accessible online, (3) involving SDPS for long-term support,
(4) involving under-represented students in CPS activities, and
(5) teaching students system specification according to prevailing industry standards.

Table 3. CPS Portal development displaying results of research spanning four years.

Portal	**Year 1**	**Year 2**	**Year 3**	**Year 4**
Cyberphysicalsystem.com PIs directing consulting services with Axiomatic Design Solutions Inc.	Web 1.0 site	Web 2.0 site	Web 3.0 site	Production of next generation toolsets for CPS design automation and management
Cyberphysicalsystem.org PIs with directing UAB graduate and undergraduate students work with K-12 mentoring	Web 1.0 site	Web 2.0 site	Web 3.0 site	Design Theory and CPS Automation Research management
Cyberphysicalsystem.net PIs directing case study implementation of KBE SoS	Web 1.0 site	Web 2.0 site	Web 3.0 site	CPS Design automation testbed output management

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