K.B. Akhilesh *Editor*

Emerging Dimensions of Technology Management

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Preface

I am happy to present a set of contents that delve into the different dimensions of technology. These chapters represent different issues of technology management across different sectors like agriculture, transport, life sciences. They also highlight the complexities, uncertainties, and the risk involved in each of the sectors.

Dr. Shailendra Vyakarnam's chapter focuses on one of the key issues in technology management that is the most problematic in the transfer of technology from research institutions and universities. That key issue is about the translational journey, which is little understood in terms of dynamics, motivations, and reward mechanisms, and legal and structural mechanisms.

Prof. J. J. Chanaron's chapter deals with different methods for valuating an innovation as presented by the available academic literature, mainly articles in peer reviewed journals. It aims at building up a typology and at assessing the pros and cons of the various methodologies, whether quantitative, qualitative, or mix. It concludes that there is no ideal innovation valuation model and that a specific composite scoreboard approach seems to be the only way to approximate.

Prof. Jie Li, Prof. Ramkishen Rajan, and Mr. Rabin Hattari's chapter examines the extent and determinants of M&As to and from developing Asia over the period 2000–2010 with particular emphasis on the financial drivers of intraregional M&As. Global liquidity and risk conditions, as proxied by LIBOR, consistently show up as being an important driver of intraregional flows.

Prof. V. G. Dhanakumar's chapter addresses the question of how commodity enterprises can improve their competitiveness through the identification of structural infirmities and development of appropriate technology to raise the level of industrial development and grow their GDP. Technology management in plantation involves the application of management skills to the discovery, development, operation, proper use of technology, and other resources to solve problems and improve efficiency and effectiveness.

Dr. Jorg Himmelreich's chapter looks at urban governance and how smart technologies are changing the face of governance. It presents an example of how the German city of Delmenhorst improved its urban governance by smart technologies and evolved as a best practice case of e-government.

Mr. Mohan Sridhar, Ms. Nandini Arunkumar, Mr. Shreyas Burji, and Dr. Taslimarif Saiyed's chapter examines the significance of nurturing technology, especially in life sciences, that has been studied, keeping in view the different ways of fostering technologies with emphasis on business/technology incubation. Also, the importance and advantages of incubators in accelerating and transforming a discovery into an innovation is discussed in brief. Furthermore, the impact analysis of incubators and their contribution towards shaping an economy is highlighted with a focus on bioincubators in particular.

Prof. Harold G. Kaufman's chapter examines an integrated talent management system for maintaining an up-to-date technical workforce. Maintaining the intellectual capital of organizations is addressed by examining the problem of knowledge and skill obsolescence among technical professionals. An open system model applied to obsolescence is presented that identifies internal system components and their interactions among each other, as well as with the external environment. The components of the obsolescence model are each addressed through a proposed integrated talent management system. Such a system utilizes appropriate talent management interventions and practices intended to develop and maintain an up-to-date technical workforce, as part of the overall organizational strategy.

Prof. A. D. Amar and Dr. Elayne Coakes's chapter looks at designing and operating communities of practice for managing knowledge, based on a survey of 1,034 knowledge managers, knowledge workers, and senior managers from organization of all types, forms, and sizes from many industrial sectors from 76 countries. The chapter shows that properly managed communities of practice (CoPs) could perform many essential tasks in creating, sharing, and applying knowledge to operations for change and innovation.

Prof. Dr. Dietmar P. F. Moeller's chapter examines airport technology management and states that airport operators must conduct the necessary actions for a proactively airport technology management to minimize the potential for operational failures and facilitate collaboration between airport authorities, airlines, ground handling, and air traffic control within the airports. Moreover, airport operators have the managerial obligation to plan and forecast future airport operations to capitalize on revenue potential and enhance service and security quality.

Prof. Reinhard Doleschal and Prof. Uta Pottgiesser's chapter explores the innovation and implementation of climate-related energy-efficient building design in India. They identify education, R&D, and climate-related innovations as the main drivers for a better quality of life and greater participation in dealing with climate change. In a five-Indian-city study, they explore the awareness of the Indian people in urban areas between the contradictory contexts of energy consumption and the needs and expectations of comfortable living.

Prof. Peter Sachsenmeier's chapter promotes the discussion about the impacts of technological innovations on technology management and its future trajectory, and also takes into account socioeconomic dynamics. It emerges that collaboration and innovation are central themes, with trust and governance playing a paramount role as determinants.

Prof. Ravi Vatrapu's chapter situates the notion of social business in the relevant macrotrends in technology, business, and society and discusses the three critical aspects of social business: social business engagement, social media analytics, and social media management. It concludes with a proposal for a large-scale collaborative research project on socially connected organizations and articulates a set of research questions, anticipated scientific advancements, and societal benefits.

Dr. Paul Jeong, Dr. M.V. Ravikumar, and Mr. Pradip Paul's chapter explores the Korean experience of technologies for sustainable development and suggests framework for emerging economies.

Prof. Arne Schuldt and Prof. Otthein Herzog's chapter explores the multiagent coordination enabling autonomous logistics. This chapter solves the implementation of autonomous control with multiagent technology. This multiagent-based solution has been used in a realistic simulation of the container logistics processes of major European retailer of consumer products. The validation shows that autonomous control is actually possible and that it outperforms the previous centralized dispatching approach by significantly increasing the resource utilization efficiency. Moreover, the multiagent system relieves human dispatchers from dealing with standard cases, giving them more time to solve exceptional cases appropriately.

Dr. Prahlada's chapter addresses the issue of how to manage technologies within the context of defence application specific to Indian context. It brings out the strengths and limitations of various players and stakeholders. Knowledge sharing, corrective actions, and road map for bringing in an appropriate technology management culture and discipline have been enunciated.

I wish to thank all the authors for their contributions to the conference. I wish to thank the organizing committee, comprising of Prof. B. N. Raghunandan, Prof. R. Srinivasan, Prof. M. H. Bala Subrahmanya, Dr. P. Balachandra, Dr. M. Mathirajan, Prof. Chiranjit Mukhopadhyay, Dr. Parameshwar P. Iyer, Prof. Anjula Gurtoo, and Prof. Parthasarathy Ramachandran. I would also like to thank the authorities of Indian Institute of Science, Bangalore. I extend my heartfelt gratitude to Springer for their support and for bringing out this volume.

About Us

Department of Management Studies

The Department of Management Studies at the Indian Institute of Science, IISc, is one of the oldest departments of management in India. It has been running post-graduate programmes and the doctoral programme since the mid-1950s. Located in the premier research institute of higher learning, it positions itself to train students in futuristic areas like technology management, business analytics, and policy analysis. The origin of the department can be traced back to 1947 when the section of economics and social sciences was setup. This pioneering step was largely a result of the long-term vision of J. N. Tata, who had sown the seeds of management education and research in the country.

This vision was given substance by the resolution of the Indian Institute of Science to establish a "…Philosophical and Educational Department, including methods of education, ethics and psychology, Indian history and archeology, statistics and economics, and comparative philology".

Indian Institute of Science

The Indian Institute of Science, IISc, owes its foundation to the practical vision and insightful dreams of a great visionary, Jamsetji Nusserwanji Tata. Ever since its inception, the institute has laid balanced emphasis on the pursuit of basic knowledge in science and engineering, as well as on the application of its research findings for industrial and social benefits. IISc is engaged in higher learning and advanced research at the cutting edge of science and technology. The institute has a highly qualified and internationally acclaimed faculty numbering 450 and a student strength of around 2,700. The institute's faculty continues to be very active in research and maintains a high annual publication output. The research findings cover a wide spectrum of scientific investigations. The institute has introduced many innovations in teaching and research that have contributed to the growth of science and technology in the country.

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Emerging Issues in Technology Management: Global Perspectives: The Need for and Understanding of a Technology Commercialization Framework

Shailendra Vyakarnam

Introduction

This chapter focuses on one of the key issues in technology management that is the most problematic in the transfer of technology from research institutions and universities. That key issue is about the translational journey, which is little understood in terms of dynamics, motivations, reward mechanisms, and legal and structural mechanisms.

There is growing desire by policy makers for innovation to solve societal problems, whether it is big challenges or economic growth. Innovation and to a greater degree entrepreneurship are seen as engines that can stimulate growth and jobs resulting in prosperity, political stability, and increased standards of living. This view, in itself, is not new. What is new is that policy makers are seeing a connection between research in universities and other institutions as sources of that growth.

For example:

> Startups are engines of job creation. Entrepreneurs intent on growing their businesses create the lion's share of new jobs, in every part of the country and in every industry. And it is entrepreneurs in clean energy, medicine, advanced manufacturing, information technology, and other innovative fields who will build the new industries of the 21st century, and solve some of our toughest global challenges (Obama 2012).

In January 2011, President Obama called on both the federal government and the private sector to dramatically increase the prevalence and success of entrepreneurs across the country. In the year since launch, the Obama administration rolled out a set of entrepreneur-focused policy initiatives in five areas:

1. Unlocking access to capital to fuel start-up growth
2. Connecting mentors and education to entrepreneurs

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3. Reducing barriers and making government work for entrepreneurs
4. Accelerating innovation from "lab to market" for breakthrough technologies
5. Unleashing market opportunities in industries like healthcare, clean energy, and education

In January 2012, Prime Minister David Cameron launched a major initiative in an attempt to boost entrepreneurship in the UK. Prime Minister Cameron said:

> Small businesses and entrepreneurs are the lifeblood of the British economy and I am determined that we, working with the private sector, do everything we can to help them to start up and to grow in 2012 (Small Business 2012).

Addressing the 99th Indian Science Congress, the Prime Minister Manmohan Singh emphasized that:

> the overriding objective of a comprehensive and well-considered policy for science, technology and innovation should be to support the national objective of faster, sustainable and inclusive development. Innovation can fulfil needs which are not met by conventional means, and this is critical in view of the numerous challenges the country is facing in delivering services to the people, especially at the bottom of the national pyramid (The Guardian 2012).

Although these are recent citations of political support for innovation, the desire and links between research outputs and innovation/entrepreneurship began in earnest in certain key locations much earlier. Silicon Valley is well recognized for its entrepreneurial cluster, as indeed, increasingly are other locations such as Boston, Cambridge,[1] Oxford, and Munich. These cities have benefited greatly from the presence of top universities, and many of the start-ups and spinouts can trace their genetic roots to the research and the people at their respective research institutions.

With the backdrop of political will, policy makers have started to formulate initiatives to assist research-based universities, which are seen as providers of talent and intellectual property to commercialize their outputs.

Common Strategies

The primary response has been the setting up of technology transfer offices[2] as indicated in a recent OECD report. The TTOs are primarily focused on the commercialization of intellectual property rights of the institutions where these IPRs are created. And, commercialization takes two main forms – licensing to industry and the creation of spin-offs.

There are mixed reviews about the efficacy of TTOs. It appears they have grown in number but are often under resourced and not managed by people with any particular commercialization expertise. This author has traveled to and met with many

[1] Kate Kirk and Charles Cotton recently published The Cambridge Phenomenon: 50 Years of Innovation and Enterprise. Third Millennium Publishing Company 2012.

[2] http://www.oecd.org/site/0,3407,en_21571361_47691821_1_1_1_1_1,00.html

institutions in India, USA, UK, Brazil, Egypt, Germany, Italy, Spain, Finland, Denmark, Australia, and Malaysia as a result of invitations to speak on the topic of entrepreneurship. In addition to personal insights from these visits and conversations, there is also evidence from literature about the challenges faced by the commercialization agenda.[3]

The Main Emergent Issues

There is indeed support at a political level, and policy makers set the context in terms of legislative changes, government-based grants are becoming more available, and industry is increasingly receptive to arrangements with universities and research institutions. But there is a severe bottleneck due to the lack of TTOs' efficacy through lack of know-how within such organizations and their host institutions.

In addition to the lack of understanding of the translational journey, perhaps because of the lack of understanding, it has proved difficult to unlock private capital in terms of investments in innovations. The lack of more general understanding of the complexity of this translational journey means that we will continue to develop innovation processes on anecdotal levels, relying on ad hoc social networks for advice.

Typical Problems of Operational and Policy Bottlenecks at TTOs

TTOs are often chaired and governed by senior academics who have never commercialized any inventions. Their focus is therefore on governance rather than on outcomes.

Boards that are set up to review disclosures and IP filing are often attended by senior academics and trusted individuals from industry rather than people with domain expertise in commercialization. This often leads to heated debates based on deep misunderstanding.

The processes and reward mechanisms are often unclear, and the very people who are to implement the policies also poorly understand them. The resulting atmosphere is one of mistrust.

People who do not have prior commercial expertise staff the offices. This is a crucial problem as they are being tasked with understanding how to negotiate with industry or assist with the creation of spin-offs when in fact they are not equipped to undertake such tasks.

---

[3] Meredith Wadman: The winding road from ideas to income http://www.nature.com/news/2008/080611/full/453830a.html

The TTO office is often seen as a policing agency rather than as an enabling organization as they are unable to secure the hearts and minds of the research community and are not seen as the first port of call by industry.

The positioning of TTOs is typically not a major strategic thrust of the research institution and may not always have the full backing of the leadership. So they remain outside mainstream activities and do not get into the social networks and industry bodies to assist them with commercialization.

The TTO is most often disconnected with the teaching agenda of the institution, and this is a major disadvantage. The author will demonstrate that connecting the teaching of entrepreneurship and creating links with entrepreneurs and industry can play a major positive role.

The list of bottlenecks is not extant, but highlights some of the major issues that can stifle the very process they are created to alleviate.

Some institutions have been working to overcome the problems listed, through a mix of training for staff of TTOs, hiring people with business development expertise, outsourcing their commercialization agenda, and establishing much more robust relationships with entrepreneurs and industry. There are good examples of such practice at places such as MIT, Stanford, Cambridge, and Imperial College – London.

The central contention of this chapter is that until we have improved understanding and a more systematic approach to the translational journey of innovations from research-based institutions, we will not see the significant changes that are expected by society and the taxpayers. The rest of this chapter sets out lessons learnt over the past 10 years and offers suggestions for improving the understanding of the translational journey of IPR out of the laboratory.

Freeing Up the Bottlenecks

At the University of Cambridge, due to funding that was made available from government to establish a culture of enterprise, one of the major investments has been in the development of education for entrepreneurship. This resulted in the creation of the Centre for Entrepreneurial Learning (CfEL). There are five flagship courses,[4] one of which is called "Emerging Technology Entrepreneurship" (ETECH Projects). This course is run three times and relies on securing emerging technologies from laboratories and having students conduct commercial feasibility studies on them. The students on one course are undergraduates from physical sciences; on another course, they are executive MBAs (part-time MBA) and finally full-time MBAs. In the latter course, we embed collaborative PhDs and postdocs to work alongside the MBAs.

It has taken a very long time for this course to get under way, because in the early years of the project, the TTO was reluctant to engage in the process. As the course

[4]A full listing of the flagship courses can be found at the website: www.cfel.jbs.cam.ac.uk

outcomes became known and understood and as staff changes took place within the TTO, there have been growing links between teaching and technology translation.

But what is it about ETECH Projects that provides wider lessons for improved innovation management?

The ETECH Model for Institutions

This section of this chapter presents an argument for such a course and the links that it can provide. It also presents briefly the curriculum that was originally developed and recent adaptations that have been absorbed from the world of practice and finally presents recommendations for improved innovation management at research-based institutions.

Why Do Institutions Need a Course Like ETECH?

At a societal level, we need more people who understand the process of translation. To be able to provide exposure to the process early in the career of graduates helps to build human capital in this field.

If we review the general management studies courses available, such as the MBA and other undergraduate courses in business, none of them targets this complex journey as part of its syllabus. Therefore, the only route to generating management expertise in this arena is through long experience in organizations and that experience does not always translate into university technology incubation contexts. Thus, we do not have any formal or systematic ways of understanding the translational journey and nor do we have any mechanisms to develop the human capital in this field.

Students are seeking practical experience with real projects so that they can relate to the world of practice. Such courses can make students more employable as they begin to understand complex commercialization processes.

The reports they produce can provide the TTO and the faculty with insights about the commercial prospects for the technologies and inventions. The reports can also act as education for the faculty.

The supervisors for such projects can be from industry thus providing helpful insights and forward links for commercialization from the institution.

There is a strengthened possibility of actual results. Students may well uncover markets and companies that can be conduits for the technologies.

Such courses provide a more robust front end to the innovation funnel. They do not replace the experienced mentors and entrepreneurs that are needed to do the hard work of actually forming commercial proposals, business plans, and so forth, but what they do is provide insights into markets and opportunities that are not otherwise available to TTOs and industry.

What Should a Course Like ETECH Contain in Terms of Curriculum?

At Cambridge, this course has developed the following minimum criteria into the curriculum:

1. *Conducting due diligence on the science and technology* – How to carry out due diligence to validate and verify the underpinning science. Understanding the importance of validating the ownership of intellectual property (who are the inventors) alongside the uniqueness of the proposed invention.
2. *Applying creativity in commercializing novel technologies* – Learning to apply principles of creativity to identify potential applications and markets for the emerging technology.
3. *Stepping stones for commercialization* – How to establish the technology and commercial advantages that will yield core propositions for commercialization. One of the early steps is to understand the proposed invention in detail, in terms of "IP" strategy and positioning against competing solutions.
4. *Market and industry assessment* – Although emerging technologies are far removed from markets/industries of today, one needs to be able to assess competing solutions and the main companies that operate in the sector and to identify the trends and dynamics of the markets and industry sectors.
5. *Routes to market* – How to identify the best routes to market and business models for commercializing early-stage technologies. In other words, when and how will the technology start to recover the investment and start to "make money"?
6. *Leadership and management of emerging technologies* – Provide an understanding of how to identify a project leader for commercialization, when and how to introduce business-aware team members, how to reward them and how to transfer the ownership of the business vision from the inventor to the entrepreneur and finally to a professional management team.

These topics are provided as illustrations only as they will vary from institution to institution. But underneath this is a more intriguing issue that has become apparent through running the course over several years.

Methodology

The methodology of running a course like ETECH requires five stakeholders to come together:

The technology transfer office holds the formal remit and must therefore engage in the process of translational activity. They can also provide links to professional service organizations such as IP lawyers and others who can assist with early vetting of technologies at a technical level.

Principal investigators and their students/postdocs whose work will be used as project stimuli. Each of their technologies can provide multiple projects for students who can develop market application projects for anyone given technology.

Teaching faculty who need to teach and to orchestrate learning by the students.

Entrepreneurs and industrialists who have prior experience of commercializing technology and can add very practical insights to the process, especially to those elements that cannot be found in textbooks. They also act as role models to illustrate to students and to principal investigators – that "it can be done." They also bring a reality check to the projects, and if things look interesting, their networks can be helpful to move to the next level.

The students need to be motivated to carry out the projects. Often the workload for such a venture far outweighs the actual number of credits allocated to such activity, and so the students need to be inspired to get into the depths of the investigation.

Courses like these need to be highly interactive, demanding outputs from students at interim stages. The core outputs from student projects can be a presentation and a written report. The first output firms up their abilities to articulate complex translational projects, and the second output provides all the arguments and detailed evidence to back up their recommendations.

Outcomes So Far

ETECH has enabled a review of some 75-technologies over the past 7 years. This has involved around 200 students and 20 principal investigators. For the purpose of this chapter, the focus is on the lessons learnt rather than the outputs.

What have we learnt about materials, processes, stakeholders, technology suitability for commercialization, and the reality of university research being used to stimulate the economy and innovation ecosystem?

Materials

One of the first lessons learnt is that none of the extant textbooks in the field of technology innovation and management provide the tools with which to actually carry out the task of assisting in the translation of research into market readiness.

The essential models in entrepreneurship textbooks summarize the process into three stages as in Fig. 1.

The entrepreneurial process consists of three stages:

1. *Innovation phase* – time when entrepreneurs generate and select ideas for new products or services
2. *Implementation phase* – a triggering event and the acquisition of capital and other resources
3. *Growth phase* – the success of the new venture and the need to acquire new managerial skills

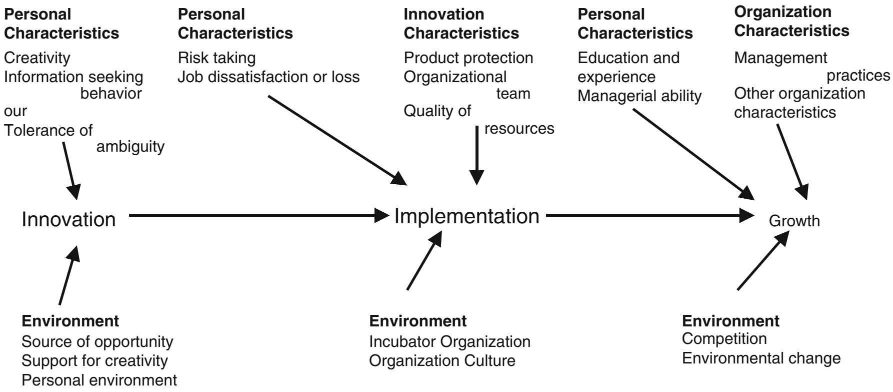

Fig. 1 The entrepreneurial process (Timmons)

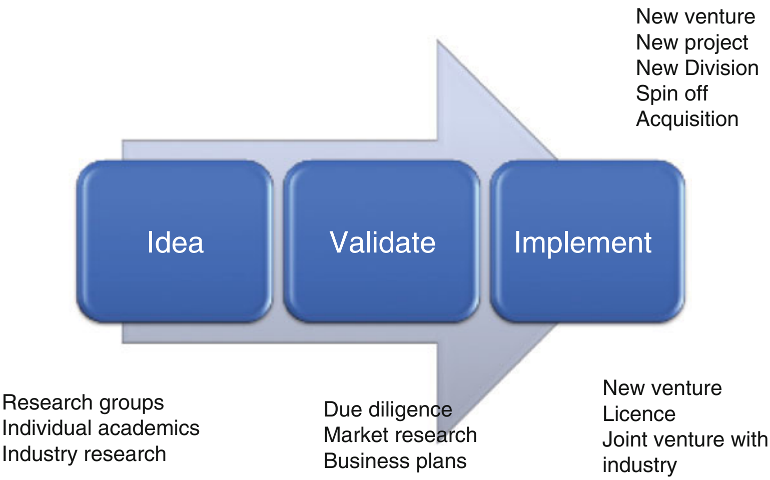

Fig. 2 Adapted schematic of opportunity recognition (Adapted from Shane and Venketaraman 2000)

Each of these phases is influenced by a number of factors such as personal characteristics, the environment, and the characteristics of the innovation as shown in Fig. 1 (Vyakarnam 2012).

This model has been articulated as opportunity recognition followed by validation and then execution. These three stages are described in numerous journal articles (Shane and Venkataraman 2000) and are adapted in Fig. 2.

These steps are also seen in corporate models of innovation that depict the three stages within funnels, where ideas are developed at the wide-open end, with validation into the narrowing part and eventually new ventures and products emerging from the funnel. Open innovation models now depict the funnel as porous and argue that ideas can come from anywhere and commercialization can take place at any

Fig. 3 What is missing in the understanding of the translational journey in innovation management

time along the funnel. The open innovation model argues that large institutions need to recognize that expertise can be anywhere in the world as they will not possess all the brightest people (Chesborough 2003).

The interesting element of these texts on innovation processes is that they completely ignore the translational journey and begin with the assumption that the technology is somehow ready for commercialization.

Figure 3 illustrates the point. TTO materials as offered by Praxis Unico,[5] a leading-edge not-for-profit organization in the field of training, have courses and content on topics such as business development, spinouts, fundamentals of technology transfer, pitching, research contracts, and UK-related impact measures. Other organizations that have deep expertise in technology commercialization are the Fraunhofer Institute[6] and ETH Zurich[7] among others. They provide hands-on support for licensing and for spinouts. It is not evident that they leverage their student bodies to scale the number of potential technologies through the funnel. There are of course many preeminent institutions that have a remit for technology commercialization, and they cover the translational journey quite well. However, the wider picture is that of a rather limited flow from disclosures, through patent filing to commercialization. Especially in recent years, the number of spinouts has reduced although the number of TTO organizations has increased.[8]

Meanwhile, the typical materials one covers in entrepreneurship areas that relate to business (as distinct from personal development) include business planning, marketing, strategy, and venture capital. What has become evident from several years of development with ETECH is that there is a gap between what TTO professionals know, what entrepreneurs work with, and the translational journey.

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[5] http://www.praxisunico.org.uk/training/

[6] http://www.fraunhofer.de/en/range-of-services/advice.html

[7] http://www.ethz.ch/industry/index_EN

[8] http://www.praxisunico.org.uk/uploads/Spinouts%20UK%20Quarterly%20Journal%20issue%203.pdf

Table 1 NASA Technology Readiness Levels

TRL 1 Basic principles observed and reported: Transition from scientific research to applied research. Essential characteristics and behaviors of systems and architectures. Descriptive tools are mathematical formulations or algorithms.
TRL 2 Technology concept and/or application formulated: Applied research. Theory and scientific principles are focused on specific application area to define the concept. Characteristics of the application are described. Analytical tools are developed for simulation or analysis of the application.
TRL 3 Analytical and experimental critical function and/or characteristic proof of concept: Proof of concept validation. Active research and development (R&D) is initiated with analytical and laboratory studies. Demonstration of technical feasibility using breadboard or brassboard implementations that are exercised with representative data.
TRL 4 Component/subsystem validation in laboratory environment: Stand-alone prototyping implementation and test. Integration of technology elements. Experiments with full-scale problems or data sets.
TRL 5 System/subsystem/component validation in relevant environment: Thorough testing of prototyping in representative environment. Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.
TRL 6 System/subsystem model or prototyping demonstration in a relevant end-to-end environment (ground or space): Prototyping implementations on full-scale realistic problems.
Partially integrated with existing systems. Limited documentation available. Engineering feasibility fully demonstrated in actual system application.
TRL 7 System prototyping demonstration in an operational environment (ground or space): System prototyping demonstration in operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.
TRL 8 Actual system completed and "mission qualified" through test and demonstration in an operational environment (ground or space): End of system development. Fully integrated with operational hardware and software systems. Most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and validation (V&V) completed.
TRL 9 Actual system "mission proven" through successful mission operations (ground or space): Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed. Successful operational experience and sustaining engineering support in place.

The gap is the result of the two worlds not being connected. The translational journey is missing a framework.

The questions raised on the missing content include:

- Technology readiness – at what stage of development has the technology reached? See, for example, the NASA Technology Readiness Levels (Table 1).
- Who actually owns the IP and when was it filed? Have patents been granted or is there any other form of protection of IP rights giving the TTO or the principal investigators the rights to commercialization?
- Is the project still at the level of publications or are there working prototypes or even proof of working concept? Do they work only in the lab or is there evidence that the technology can function outside the lab?

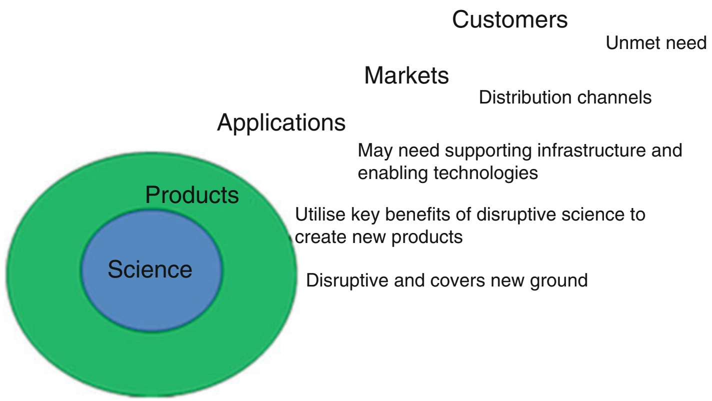

Fig. 4 Evolving from the core (S. Vyakarnam)

- Has there been any kind of study to demonstrate market need? Often this is limited to narrow considerations, but with emerging technologies, it is essential to search for global opportunities.
- Can early funding be secured from potential clients to establish that there is a need and that organizations are willing to engage in the process of converting an idea into a product?
- Is there scope of joint ventures or open innovation style work groups to codevelop products? Often a disruptive technology will require a complete set of stakeholders to develop the standards, applications, and surrounding regulatory standards.
- Are there codevelopment opportunities of funding that mix government grants with industry investments? This may be needed to mitigate commercial risk. Governments can play a crucial role to move technologies forward to the point that the private sector can take up the commercialization of resultant products and services.

This author has attempted to capture the translational journey in two ways. The first (Fig. 4) depicts how a scientific discovery goes through a number of stages to include, in the first instance, the conversion of scientific discover or invention into a product or service of merit in the marketplace. The product or service needs to be turned in a holistic set of features and benefits that clients can engage with, and this opens up the question of routes to markets, segmentation, and finally definitions of unmet needs that the evolved technology can address.

As an example, if one takes the invention of the light bulb, it was not possible to truly commercialize this until electricity, the development of fittings, switches, trained electricians, and the design elements needed to install in homes, in offices, and on streets were more widely available. There has been continuous development of lighting, with tube lights and now with LEDs, all of which are only possible because of the systems that are now in place.

This is a simplified figure, and one can imagine radiating out from the core in numerous directions with a discovery that may have multiple applications. The headline

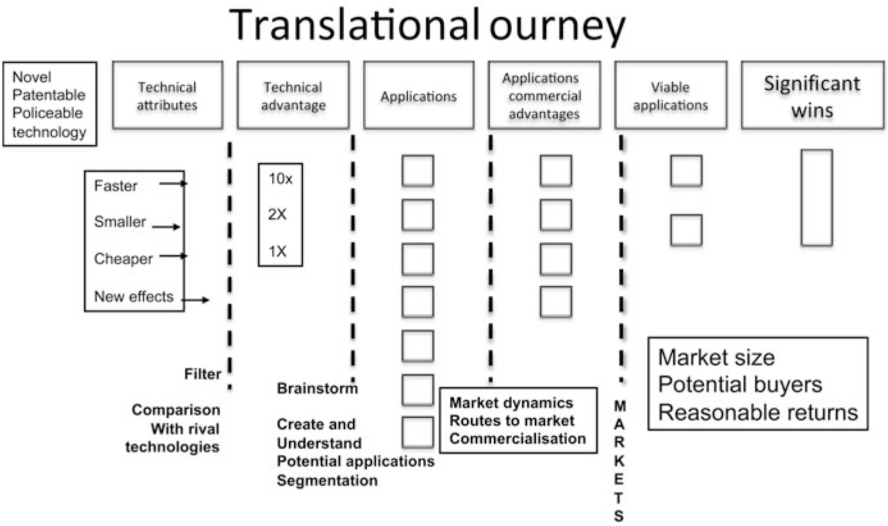

Fig. 5 Translational journey from lab to market

descriptors need to be turned into task lists to enable managers of TTOs, entrepreneurs, and investors to make decisions and choices.

It is important too to understand the possibilities that result from this process, for example, when to file for IP, what exactly is one filing, and is there likely to be a more lucrative piece of IP that comes later? There are risks of filing too early because those who truly understand the marketplace can box in a core piece of IP later. These kinds of issues can only be dealt with once a deep dive has been conducted into the technology/market interface.

In reality, research from research institutions is rarely ready for the market, and a lot of work is needed to get the technology, product, and commercial value proposition ready for markets.

The translational journey in Fig. 4 can be combined with the entrepreneurial process described by Timmons and by Shane and Venkataraman and results in the following seven-stage framework in Fig. 5.

1. *The actual discovery or invention*
   How novel is it when compared to those that might be from other competing laboratories? How "leading edge" is the discovery? What are the publications in the area? Is it patentable in itself? This first stage can be refined using the NASA Technology Readiness Levels. Of course for technologies in fields other than rocket science, the TRL must be used as a metaphor.
2. *Technical attributes*
   Does the discovery or invention actually create major advantages over rival technologies? Is it better, faster, and cheaper, or does it create completely novel effects that might then open up new markets that were not otherwise possible?

3. *Technical advantages*
   If there are advantages, are these sufficiently exciting in the sense that customers would be willing to switch over? Are the advantages 10 times better or even more in terms of price/performance, lifetime costs, or other metrics that are used by customers?
4. *Applications*
   What might be all the opportunities for the discovery or invention? It is not sufficient to address only one market. There may be many applications for the technology, and this is important to make decisions about IP filing, investments, and creating road maps that are attractive to investors and management teams. A full-scale creative exercise is required at this stage of development to explore where and how to enter various market opportunities. Teams should be encouraged to find at least 5–6 major opportunities to get started with ideas of where to explore those that are commercially viable. This is quite hard for those with scientific training, as they will start to evaluate the opportunities too early and become judgmental about opportunities. Multiskilled teams should undertake this task.
5. *Applications commercial advantages*
   From a large landscape, teams can undertake some detailed analyses of markets and competitors and iterate around issues of technology development, product design, and other detail to narrow down from a broad set of opportunities to a more focused set of markets/customers.
6. *Viable applications*
   It is at this stage that one should engage in highly experienced entrepreneurial teams that have domain expertise, so that a hard-nosed assessment can be made and perhaps detailed plans can be set out for commercialization. It is at this stage that value propositions can be developed for clearly defined market segments and decisions about whether to spin out a venture or develop license agreements with selected companies can be taken.
7. *Significant wins*
   Finally, if the work has gone well with a strong wind from behind, the chances of success are increased through such a process of technology and commercial feasibility studies.

Stages 1–3 of the translational journey in Fig. 5 can be answered with help from using the NASA TRL index (Table 1). This table is most helpful as it can also assist in setting timelines and budgets for understanding the complexities of converting a scientific discovery or invention into usable products and services. In aerospace currently, it is assumed to take approximately 1 year per TR Level. High tech and investor patience would run out at those speeds, but the levels themselves are highly usable.

Progress onward from stage 3–4 of the translational journey can be developed with the help of the technology adoption life cycle model, but in an updated form. This is because the nearness to markets and customers starts to come nearer to focus, and a strong market-led strategy is needed for the further development of the innovation.

Technology Adoption Life Cycle

There has been a highly influential text by Geoffrey Moore in his two books: Crossing the Chasm and Inside the Tornado. He draws on the work of Everett Rogers (Geoffrey Moore 2006) building on the technology adoption life cycle. In terms of generally available materials, this work is probably the most helpful for technologists to fill in the missing content in the translational journey.

Moore segments the markets and then builds a case for how managers can develop product and entry strategies according to the segments.

The Market Is Segmented into Numerous Stages

Innovators and early adopters – individuals who will experiment and explore new products when they are first made available. They do not mind if things do not work as promised. They are happy to tinker with the product and the service. There are very few people who fall into this market category.

Then comes the mainstream marketplace, which is very different. Here, customers want to buy things that are proven and have a full product offering that includes back, aftersales, augmented value propositions, and so forth. And it is this marketplace that provides the real scope for growth. Between the first phase of early adopters and the mainstream market, there is thought to be a chasm into which many high-tech firms fall. They are unable to adapt their offerings, management teams, and resource capabilities to meet the needs of the mass market. The use of the Everett Rogers model by Geoffrey Moore has become legendary in high-tech marketing. It is a useful text and is based on entrepreneurial strategies giving executives a language with which to take their plans to boards and investors.

It is not used enough and the mysteries of failure continue to haunt investors and entrepreneurs of early-stage ventures. Even in large corporations with significant innovations, this model has proved difficult to implement, because they actually often lack the internal mechanisms to get their projects to early adopters. Their systems are set for mainstream markets, and this in turn makes it attractive for small firms to eventually target larger firms for being acquired. They can prove the market and the product; the big company can then take them into the mainstream. At least that is the theory.

But there is more than one chasm and a better understanding of the later stages of the translational journey is needed.

But There Is More than One Chasm

The process can be seen in Fig. 6. The translational journey reaches its first chasm once it has generated ideas and applied filters such as the NASA TRL. At this point, the decision needs to be made about developing proof of concepts and demonstrators and creating business plans. Between the two stages, there is likely to be a need

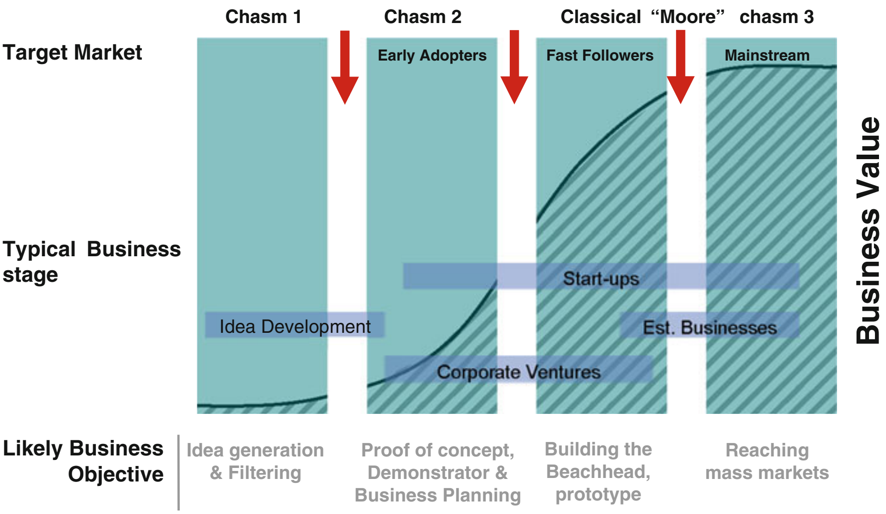

Fig. 6 Triple chasm model (Phadke 2010)

to raise funding, file for IP, hold confidential discussions with potential clients, and get market feasibility studies. Decisions will need to be made about what type of demonstrator to build, in turn raising questions about who the innovator client organizations will be.

Assuming that the first chasm is crossed successfully, the next stage is to get beyond the "innovator" clients to those who are early adopters. They need different buying value propositions. For them, it is not about exploration of new technologies; it is more about finding out if the technology solves a particular problem for them (the so-called unmet need). They may be willing to pay a premium at this stage as they realize that the solution is not yet fully worked up. They also need to see results from the demonstrator.

From here, the technology can reach the third chasm, which actually is the chasm that Geoffrey Moore talks about in his two books. This is where the venture has probably been well established and the key objective is to gain scale. The customers are now completely different, wanting price/value, needing a complete service with augmented offerings. They will not tolerate exploration or high-priced experiments with their problems.

The TRL methodology is used in aerospace and in aircraft manufacture, but has so far not made its ways into empirical testing in translational research situations. The NASA TRL methodology is presented below for information.

Discussion

Society is demanding more from its research institutions in terms of converting blue-sky research into applications. For many years, research institutions have not been answerable to the taxpayer, and as governments become more aware of their scare resources, universities are being expected to create additional sources of income from leveraging their research.

Beyond the financial imperative, there is growing recognition that innovation can provide solutions to big problems like climate change, poverty, affordable healthcare, and water paucity. And research does exist in these areas, but how to bring them out in financially sustainable ways remains the big challenge.

It is in this context that mechanisms for scalable approaches are needed and a workable translational journey needs to be developed. Each step of the journey will need adapting to local needs; for example, at the idea validation stage, there is a framework that can be adapted from the NASA Technology Readiness Levels framework. Over several years of running ETECH, we have found that many projects have reached between TRL 2 and 4.

Perhaps because we were not using such a readiness framework or the visionary eye of the principal investigators and/or the hype surrounding academic citations has resulted in companies being formed at premature stages. This has caused many failures and inappropriate funding and IP strategies have been pursued. So, the simple inclusion of a TRL framework may assist at the early stages of development.

For the later stages, where TTO staff are not connected to markets and customers, there is need to manage the chasms more carefully, to combine creative market making skills with risk mitigation. Using a tool such as the triple chasm model and working with people with deep domain expertise will more likely provide positive results.

There are of course many tools from the box of management literature, such as from strategy, marketing, and finance, that are needed to augment the process described above, but these tools can be easily discovered when using the translational journey approach to innovation management.

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Innovation Valuation: Guesswork or Formalized Framework? A Literature Review

J.J. Chanaron

Introduction

Most management scholars and practitioners would agree that innovation is nowadays a key source of economic wealth at both microeconomic and macroeconomic levels. If there are obviously still ongoing debates on the definition and understanding of the process of innovation, assessing the potential value of an innovation remains a key issue which has not been addressed satisfactorily in the academic literature. As stated by Boer (1999), valuation is about quantification and, when possible, in monetary terms.

As an intangible asset, such measurement is a real challenge since it is difficult to link an innovation, whether it is a new product or service, a new process, a new organization or a new market, to specific business outcomes, measures or value metrics such as profits, market shares, cost reduction, operating leverage, R&D expenditures, number of patents and number of citations. According to Kannan and Aulbur (2004), intangible assets are innately hard to be quantified since they include multiple organizational as well as individual variables and simple financial evaluations fail to "take cognizance" of their complex nature.

As stated by Coad and Rao (2006), "an innovation strategy is even more uncertain than playing a lottery, because it is a *game of chance* in which neither the probability of winning nor the prize can be known for sure in advance". The authors

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conclude that innovation will probably never be based on rational decision-making and that "successful innovation… requires risk-taking and perhaps just a little bit of craziness". In our opinion, this makes even more important and crucial the question of valuation *ex ante.* But as stated by Bucher et al. (2003), technology, and therefore innovation, valuation, defined as the measure of business impact of a given technology, is the weak link in the technology intelligence chain. As pointed out by Park and Park (2004), "it is never surprising to hear that technology valuation is not a science but an art. It is an intractable task to quantify a priori the link between techno-logical research and commercial payoff and valuation is a subjective activity… very much like beauty that is framed in the eye of beholder". Boer (1998) added that innovative technology is "disturbingly intangible, often financially invisible, very risky and dependent on linkages to other assets for realizing its value".

The main objective of this chapter is to contribute to the debate in examining, through an extensive critical literature review, whether innovation valuation is an exercise of pure guesswork or if it could be based on a formalized and efficient framework, and then be applied in real conditions to the benefits of entrepreneurs and innovative managers.

Following Andriessen (2004), Czarnitzki et al. (2006), and Chiesa et al. (2005), interest granted to innovation valuation comes from several perspectives:

1. The need for top managers, and in particular, their accountants, to value innovative intangible assets to support strategic decision-making, to indicate transfer pricing in mergers and acquisitions, or to settle legal cases such as unfair competition and patent breaching. In other words, "what is measured gets managed".
2. Since a "market for technology" is emerging, assessing the value of technology is also essential in buy/sell transactions.
3. The willingness by economists and investors to build up proxies in order to measure the real value of firms as a guide to investment, a consensus having emerged that intangible assets are a substantial part of such real value.
4. The effort by economists and policy makers to quantify the contribution of innovation to growth and corporate strategy.

The need for a tool measuring innovation is so crucial that the Secretary of Commerce of the USA created an Advisory Committee on Measuring Innovation in the Twenty-first Century Economy in 2006 which actually produced its official report in 2008 (Schramm 2008). Boer (1999) confirmed that quantifying the value of technology and R&D projects – and obviously innovation – is essential for many people: accountants, buyers and sellers of licensing agreements, investors, patent holders, financial managers and executive decision-makers.

The importance of an efficient valuation tool is indeed illuminated by the high failure rate of innovations. As emphasized by Amram (2005), only 10–15% of new ideas are commercially successful. Since an idea becomes an innovation when such a market success is granted, assessing its value is then vital.

R&D, Innovation, Productivity and Market Value

Innovation and Market Value

A huge amount of academic literature has been dedicated to the relationships between innovation and market value, even though innovation measurement is limited to R&D expenses and patents (Hall 1993, 1999). According to Hall (1999), R&D assets, i.e. spending on or stock of R&D, are valued by financial markets, and the number of patents is also informative but with a weaker correlation, while citation-weighted patents are slightly more informative. Hall and Oriani (2006) state that most studies since the seminal work by Griliches (1981) used market value as an indicator of the firm's expected results from investing in R&D. Such evaluations are analysing ex post valuation of input to the innovation process. This is not indeed providing an accurate and representative value of an actual or potential innovation.

Obviously, valuating innovation is important when mergers and acquisitions are concerned for assessing the value of the targeted firm and the potential impact of the acquiring firm. After Burgelman (1986), Christensen (2006) confirms that acquisitions have been an increasingly popular way for mature organizations to gain access to new resources and skills and that acquisition of companies possessing complementary technological capabilities and entrepreneurial abilities may be seen as a way for large corporations to restore or increase their innovativeness. An important body of literature targeted to help organizations understand the value of technology and innovation through acquisitions (Hitt et al. 1990, 1996; Ahuja and Katila 2001). But again, such literature fails in suggesting reliable evaluation criteria and methods.

Using patent citations as an indicative value of innovations has been advocated by Trajtenberg (1990). He found out that patent counts and citations are "richer and finer and have a wider coverage" than R&D expenditures. They are also continuous in time. Unfortunately, such data fail to measure all kinds of innovations and would require a stabilized definition of the concept and the process of innovation. As emphasized by Amram (2005), the expected value of a patent is difficult to assess and rests on whether the holder has the intent, time and resources to invest in a long process from the idea to commercialization. The author suggests that most if not all patent attributes are weak measures: number of references (forward citations), number of claims, extent of multi-country filings, number of backward citations, litigation or opposition claims. The value of patent is strictly "context-specific", and valuing patents is inherently difficult.

R&D and Productivity

Research linking R&D investment and productivity growth is also inappropriate to help valuating innovation since it is at macroeconomic level. The measurement of the knowledge stock meets theoretical as well as practical and methodological challenges (Esposti and Pierani 2003). All models reviewed by Bontis (2001) that pretend to evaluate the intellectual or knowledge capital do not measure the value of a current or contemplated innovation.

A “quick-and-dirty” or simple model of technology valuation for brand new project might just incorporate what Boer (1999) names technology marketplace data such as adding R&D spending and early invested amounts by venture capitalists and business angels (early rounds of fund raising). Then the value could also integrate amounts raised at the initial public offering (IPO).

It is obvious that significant amounts of investments in innovation are not captured by existing statistical systems such as R&D expenditures, number of scientists and engineers and patents.

Innovation and Sales Growth or Cost Reduction

As emphasized by Coad and Rao (2006), the contribution of innovation to firm’s growth is obviously very difficult to observe in particular because it may take a long time to convert increases in economically valuable knowledge into economic performance due not only to the time needed to succeed at each stage of the innovation process but also to the huge cost of development and investment to be implemented after the discovery. The authors conclude that most academic contributions in measuring innovativeness as defined AK by Griliches (1990) in the model presented below (Fig. 1) through proxies such as innovative input (R&D) and outputs (patents) are “rather noisy” and then controversial. Again, they recognize that R&D expenses are an input, although not the only one, to the innovation process and that patents are a very partial approach to the output of such process.

While Rao (2009) is not aiming at valuing innovation, he suggested measuring the value of two kinds of innovation with two different offshoots: on one hand, continuous improvement of existing products and services which enhanced value leading to increased market share and profitability; on the other hand, establishment of a new market resulting in a monopoly position.

Another dominant metric is the evaluation of cost reduction or profit increase associated to an innovation (Townsend 2009). According to Bingham (2003), cost reduction is the first target of incremental as well as breakthrough innovation. One of the key economic objectives of innovation is to gain competitive advantage over competitors with cheaper products or temporary monopoly position as first mover. To create value, any innovation must have a market. In the case of an incremental innovation, since it is addressing an existing market, this should be reflected directly or indirectly in the forecasted income through potential increase in market share and/or cost or capital savings. When the innovation is a radical breakthrough or “new to the world”, predicting the potential market through marketing research is simply impossible (Boer 1999).

Obviously, a key difficulty is to identify which revenues or cost reductions are attributable to a particular technology or innovation within total income or total

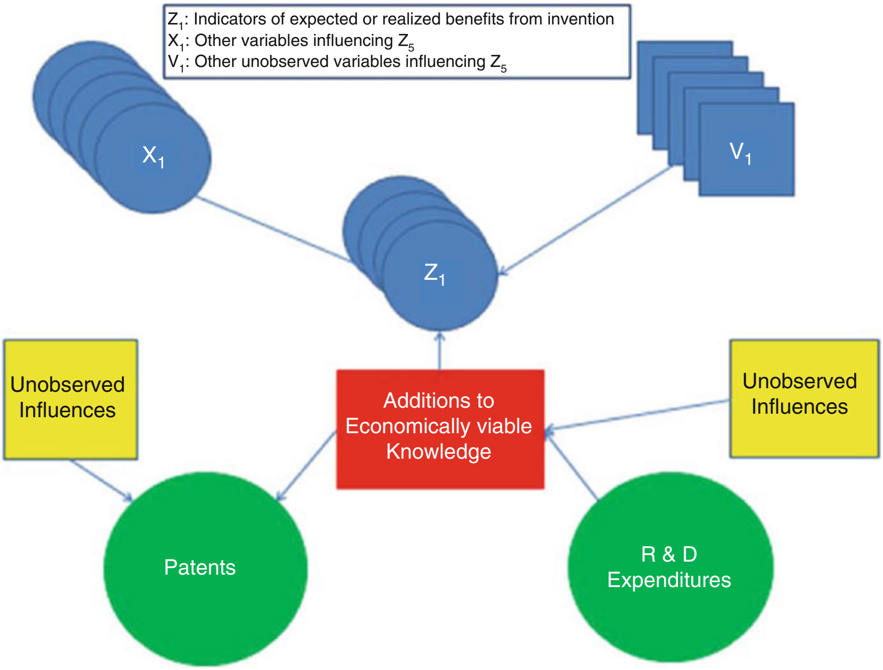

Fig. 1 Griliches' model (1990)

expenses. As put by Katz and Olsen (2008), when there are no identifiable revenue or cost, the only shortcut is to apply the percentage of R&D expenses in the total expenses as a proxy!

Innovative Project Management

According to Wang (2007), three methods are currently used for valuating technology innovation and adoption projects: net present value (NPV), decision trees and real options. NPV underestimates the innovative product compared to the existing benchmark in particular because the market size is not discernible before the advantages of the innovation are fully known. Based on practitioners' knowledge, decision tree modelling can become very complex and then be impracticable in the complex circumstances of innovative projects. Real options applied to R&D projects look like the most appropriate method since an option put on a technological innovation could be implemented if the market conditions are acceptable. But real options face also high methodological uncertainties, in particular because hypotheses valid in a financial investment context are not satisfied.

The use of real options has been popular with a growing number of scholars and consulting experts (Boer 1999) when assessing technology-based projects.

Table 1 Mankins' levels

Technology readiness levels	Cost
Basic principles observed and reported	
Technology concept and/or application formulated	
Analytical and experimental critical function and/or characteristic proof of concept	
Component and/or breadboard validation in laboratory environment	
Component and/or breadboard validation in relevant environment	
System/subsystem model or prototype demonstration in a relevant environment	
System prototype demonstration	
Actual system completed and qualified through test and demonstration	
Actual system proven through successful operations	

Source: Adapted from Mankins (1995) by eliminating space industry references

But indeed if real options approach looks attractive for technology diffusion and implementation, i.e. when the technology is well known and defined prior to the actual use of the methodology, it is much more challengeable in the case of a brand new emerging innovative technology.

Very few scholars tackled the issue of the efficiency of different methods. According to her survey, Wang (2007) concluded that decision trees and real options are more efficient than net present value at the start-up stage of an innovation. This is confirming earlier conclusions by Varila and Sievänen (2005). But Steffens and Douglas (2007) demonstrate that decision tree analysis should be preferred to real options valuation. They even state that real options valuation should be forgotten when dealing with high uncertainty. Paulson et al. (2007) add that real options and portfolio selection paradigms cannot really deal with high-risk environment which is indeed the usual situation for innovation. Wu (2005) suggests that real option should integrate also the so-called jumps in project value (up or down) due to the declaration of innovation success or failure.

Technology readiness levels (TRL) are complementary ways of measuring the maturity of a given technology as well as comparing maturity levels of different technologies. In his white paper to the NASA, Mankins (1995) suggested nine levels (Table 1).

While initially designed for marketing purposes, technology readiness index (TRI) might provide an idea of the anticipated value of an innovation by customers and users. As pointed out by Parasuraman (2000), the technology readiness construct refers to people's propensity to embrace and use new technologies. The author suggests to measure four dimensions related to the adoption of the new technology: optimism about the impact on home life and at work, innovativeness acceptance, discomfort appraisal and insecurity assessment. Such dimensions are then completed by measuring the time frame for adoption (already have, next 12 months, no plan to get), for use (already used, plan to use in the next 12 months, no plan to use) and perceived desirability (on a scale 1–6 from very undesirable to very desirable).

Mathews (2010) suggests developing an innovation portfolio architecture in which technology readiness level as well as attrition rate are specified together with the level of alignment to the business strategy and an evaluation of potential net benefits as well as development cost. Obviously each evaluation should be regularly updated. But Mathews (2010) also points out that, by its very nature, an innovation is highly uncertain and typically governed by a weakly defined "strategic intent". He adds that innovation concepts are often not ready for presentation to senior executive managers due to the uncertainty of their value and their immaturity which are mainly based on "strategic thrusts". Recently, the author recommended to select value metrics – net present value, future options, etc. – which are appropriate to various strategic options for a given innovation: direct benefits and costs, diffusion time frame, maturity/uncertainty, related benefits and costs (Mathews 2011).

Technology Assessment and Technology Forecasting

Despite the fact that they are not particularly focused on quantitative valuation, technology assessment and technology forecasting and foresight methods could certainly help to approach some of the indicators used in valuation exercises and in particular the time frame of the innovation from invention to diffusion as well as customer/user acceptance. Such a point of view has been presented by Baek et al. (2007).

Technology forecasting methods as developed by Jantsch (1967, 1973) such as relevance trees, morphological research, brainstorming, Delphi and scenario building are complementary in estimating the noneconomic value of a particular technology within a chosen time frame. These methods provide qualitative insights on the possible scheduling as well as alternative paths for the introduction and diffusion of a particular technological innovation.

Technology assessment methods have been developed in the 1960s in the line of technology forecasting studies, in order to evaluate all the impacts of technology (when introduced, extended or modified) on various dimensions of the society, especially when these effects are unintended, indirect or delayed (van den Ende et al. 1998). Constructive technology assessment approaches (CTA) help in particular when shifting the focus away from assessing impacts of new technologies to broadening design, development and implementation processes. As recently emphasized by Van Merkerk and Smits (2008), CTA "strives to improve the societal embedding of technologies, which means the extent of integration with relevant industries and markets, the admissibility with regards to regulation and standards, and the acceptance by the public". The authors pinpoint that in the 1980s, technology assessment was used to support actors involved in decision-making in innovation. A real-time investigation will obviously be a real advantage (Guston and Sarewitz 2001).

Table 2 Kaplan and Norton's innovation measures

Goals	Measures
New products	Per cent of sales from new products
Customer partnership	Number of cooperative engineering efforts
Technology capability	Manufacturing geometry vs. competition
Manufacturing excellence	Cycle time
	Unit cost
	Yield
Design productivity	Product efficiency
	Engineering efficiency
New product introduction	Actual introduction schedule vs. plan
Technology leadership	Time to develop next generation
Manufacturing learning	Process time to maturity
Time to market	New product introduction vs. competition

Composite Measurement

Scoreboard Approaches

In their seminal article on balanced scorecard, Kaplan and Norton (1992) suggested a set of measures for innovation and learning capability into a metric to be fulfilled by members of the innovating organization (Table 2). They proposed a mix of financial and nonfinancial benchmarks, using extensively executives' perceptions. Nobody would challenge that the balanced scorecard is a powerful management system and not just a sophisticated measurement system (Bontis et al. 1999). It keeps track of many dimensions in a systematic way but is excessively rigid and static, and since it is company-specific (internal), it does not allow external comparison. As pointed out by Marr and Adams (2004), this is not a measure on intangible assets since Kaplan and Norton's concepts are unaligned, inconsistent, incomplete and potentially very confusing. Since they do not produce any clear and non-challengeable definition of categories such as innovation and new product, the balanced scorecard is unable to give an acceptable assessment of the actual and, *a fortiori,* of the potential value of an innovation.

As set up by the OECD (1999), multiple indicators could be used to benchmark knowledge-based economies, forming an interesting science, technology and industry scoreboard (Martin 2004). But indeed this is not a valuation of existing or potential innovation at firm level.

Such evaluations based on multiple variables or components which are measured separately suffer from an obvious complexity. When combined to form a composite aggregate, they are challengeable due to the aggregating methodology itself (Bhartesh and Bandyopadhyay 2005).

Table 3 Breakthrough innovation valuation tool

Contribution to the company renewal	The extent to which a project will fuel new lines of growth, either by causing us to learn about and move into domains that are new to us or to develop new competencies that we have not yet mastered
Contribution to the company growth	The extent to which a project leverages our current strengths to develop new avenues for top line growth
Impact on the market	The extent to which a project has the potential to bring wholly new benefits or significant leaps in known benefits to the market
Impact on the portfolio	The extent to which a project helps bring the portfolio to a healthy balance on any of our desired dimensions for portfolio diversification
Impact on team capabilities and pace of progress	The extent to which a project team is exhibiting the appropriate set of skills and competencies and is making appropriate progress given the project's stage of development
Impact on firm capabilities for this project	The degree to which the firm has the resources, motivation and capability to bring this project to fruition
External environment's impact on the project	The degree to which regulatory, competitive, value chain or customer reactions could prevent successful commercialization
Portfolio health	Overall appraisal of the value of the portfolio as a whole

Source: Paulson et al. (2007)

Portfolio Evaluation Tools

Paulson et al. (2007) is probably one of the most interesting academic contributions to the issue of innovation valuation. It is focused on breakthrough innovation and is suggesting a questionnaire to be filled in by a panel of decision-makers within the firm addressing the following eight potential impacts of a given innovation (Table 3):

The various questions included into indexes 1 to 7 are to be answered by several technology managers on two dimensions:

1. The relevance of the project, graded 0 if not relevant and 1 if relevant
2. The value level, on a scale 1–5 from very low to very high value

This very interesting methodology is essentially based on relative evaluation, i.e. comparing and finally ranking different projects of radical innovations within a portfolio of a given organization. It is then inappropriate, by principle, to absolute valuation, i.e. when dealing with one particular innovation.

Analysis and Conclusions

A majority of intellectual contributions on technology valuation emphasize the following "model" (Fig. 2):

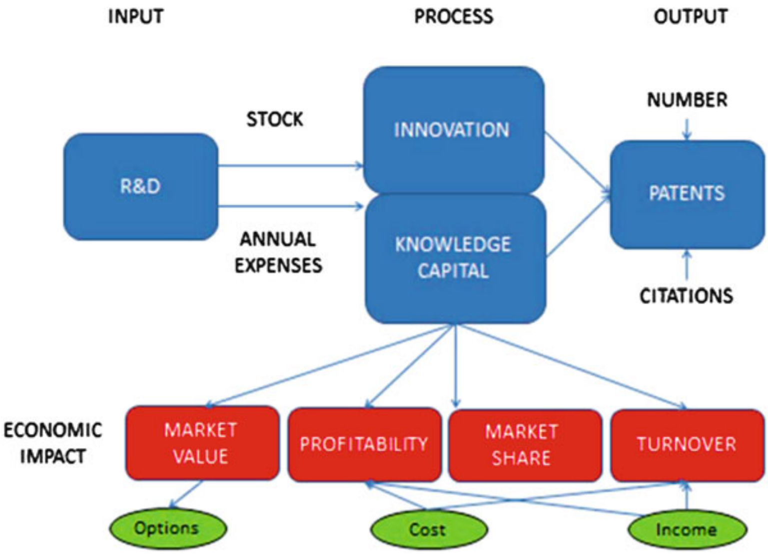

Fig. 2 A well-accepted model

The following weaknesses might be pointed out:

- As already mentioned, measures of input and output fail to express what they are designed to assess and suffer of multiple drawbacks, including difficulty in collecting good quality data. Such an input-output model is by far oversimplifying the real complexity of the process.
- The language used is often not very consistent creating confusion: valuation or measurement, value measurement or value assessment (Andriessen 2004).
- Making innovation and knowledge capital and sometimes intellectual capital or intellectual property or assets as quasi-synonyms is a controversial and challengeable shortcut. It is certainly confusing and incorrect (Grajkowska 2011).
- Based on information produced through the current accounting framework, measures only recognize past transactional items (Kannan and Aulbur 2004).
- Most indicators only give a partial view of the reality. Many are interrelated and only reflect the performance of a few stakeholders. Therefore, their interpretation can be ambiguous (OECD 1999).
- Secondary effects of innovation are not integrated in most metrics, neglecting qualitative impacts of value from changes to the organization, its structure, culture, markets, other innovations and client or supplier relationships (Townsend 2009).
- Innovation is still a concept of debates amongst scholars as well as managers and is a highly localized phenomenon (Townsend 2009) shaped by very high contextual driving forces specific to firm, to an industry or to a stakeholder (innovator, users, suppliers, etc.).

- As highlighted by Chesbrough (2004), almost all valuation metrics for innovation are static measures when innovation is dynamic by essence.
- The majority of measures (when available) fails in distinguishing phases along the sequential process of innovation or its "S" curve representation: should it be focused on the start-up phase or closer to the maturity phase? They also fail in making a distinction according to the very nature, namely, incremental or disruptive, of the innovation. Obviously valuating an innovation when it is at market test or very close to market entry is very different from the value which would be attached to a concept in development or an early-stage prototype (Grajkowska 2011).
- Very little is said about the capability of real-life organizations concerning the operationalization of the various valuation approaches and the related challenges (Suomala et al. 2012).

Obviously, any measure could use different valuation ways. According to Renkema and Berghout (1997), there are two kinds of consequences of innovative investment: financial value which can be expressed in monetary terms – costs and benefits, profits, etc. – and nonfinancial value which cannot be expressed in monetary terms and might be measured by proxies such as contribution in product range and variety, strategic match, competitive advantage, uncertainty reduction and organizational change (e.g. new business model, spin-off).

As stated by Kannan and Aulbur (2004), the multiple identified limitations can be overcome, indeed partly, by "integrating financial measures with perceptual, process and system measures" or by using a mix of scoring, indexing and monetary valuation indicators (Park and Park 2004) which could then be built into a dedicated innovation valuation model (IVM).

The methods and tools identified in this literature review can be summarized in a matrix according to two items: the economic nature and the complexity of the metric (Fig. 3):

1. Most if not all available measures to evaluate innovation are highly controversial and challengeable.
2. The only acceptable track is a composite valuation model mixing the maximum of quantitative as well as qualitative indicators into a comprehensive scoreboard or set of evaluations.
3. It should incorporate a complementary model approaching the process of innovation with a global vision integrating technical, economic, industrial and societal dimensions.

It should be pointed out, following Boer (1999), that any valuation exercise is also incorporating a human side. "Value is, after all, very much like beauty – it is framed in the eye of the beholder. And every beholder is different". It is obvious that decision-makers, financial analysts, investors, engineers and scientists and R&D managers will have different expectations and opinions about the potential economic value of a given innovation. Any decision should then take into account such diversity and should probably require some kind of consensus building. Obviously, the model should be based on hypotheses evaluated and calculated by

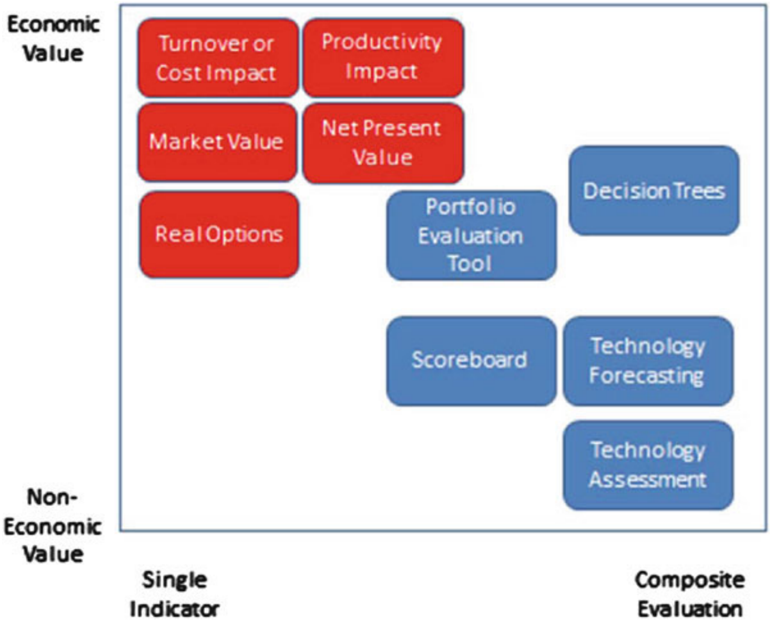

Fig. 3 A matrix of measures

several recognized experts who should be able to bring adequate information and data and to justify the reliability of their assumptions. Such team of experts should incorporate several functions such as R&D and engineering, marketing and sales, finance and accounting and corporate strategy and planning. The experts should also take into account the overall context of the potential innovation which deals very complex dimensions such as social, environmental, political and ethical issues. Key difficulties are indeed the amount and analytical quality of data as well as qualitative information to be collected ex ante, i.e. when the innovation is still at early project stage. As stated by Boer (1999), consulting (…) for expert advice in the early phase of a project may seem premature and naive. But on one hand, nobody will seriously challenge the urgent need for an efficient tool for innovation valuation (Green and Revilak 2009). On the other hand, as emphasized by Schramm (2008), measuring innovation "will necessarily be a very long, maybe never-ending journey". Grajkowska (2011) adds that it is difficult to make a credible prediction about the future market value of a radical innovation launched by a start-up, allowing only assumptions to be made. Through a survey with 126 Finnish managers, Suomala et al. (2012) concluded that estimating payback time and amount of revenues/cost savings during the next 10 years would be important factors but at the moment too difficult to be measured.

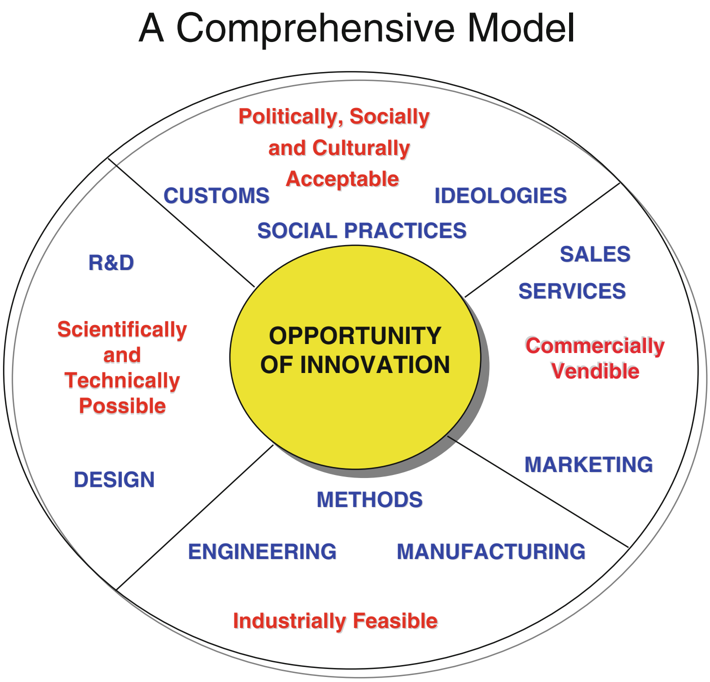

Fig. 4 A comprehensive model (Source: Chanaron 2010, 2011)

It is indeed difficult to formulate a particular recommendation to practitioners facing the issue of valuating an innovation. As stated by Lagrost et al. (2010) in their complex system for intellectual property, there are several dimensions: internal-external objective; transactional-financial-administrative-legal purpose, all having their key variables; stakeholders such as investors-licensees-creditors-advisors-accountants-authorities-shareholders; quantitative-qualitative value; minor/break-through innovation; and then the cost-revenue-market value indicator. Most valuation models are weak because they are biased by the "desire of interested parties in producing results that exceed…what can be accomplished" (Amram 2005), providing wildly misleading valuations and obscuring the reality.

Further research is obviously deeply needed in order to overcome some of the theoretical issues as well as methodological difficulties inherently associated to any innovative activity. Applied research is also required on illuminating case studies – success of failure – in order to test new metrics in real market conditions. Since the importance of valuing potential innovation to managers facing decision-making is unanimously recognized, progressing in both understanding and quantifying real business situations is a challenge that scholars should address.

A very initial research avenue could use the following model of innovation (Fig. 4):

Innovations, namely, new products, new services, new processes, new business models, or new organizations, new markets, are successful when they are simultaneously:

1. Scientifically and technically possible, i.e. when they have the technical performances expected by customers and users
2. Commercially vendible, i.e. when their price meets the demand as well as the after sale and maintenance costs
3. Industrially feasible, i.e. when their manufacturing costs and quality are satisfactory to all stakeholders
4. Politically, socially and culturally acceptable, i.e. when they get political support and full customer acceptance

It is assumed that potential success of any given innovation would happen only when and if key variables from these four systems (possibility, vendibility, feasibility and acceptability) are satisfied or that failure would happen when key conditions of one or several of these systems are not fulfilled. That means that the potential value of an innovation would be determined by the four dimensions.

Each of the five meta-dimensions could obviously be detailed into very precise variables or proxies that could be approached by quantitative or qualitative measures, including through a detailed questionnaire for a survey of concerned stakeholders such as researchers, industry experts and consultants.

An immediate foreseeable difficulty is the unavoidable sector-specific or technology-specific vision[1] which will inevitably lead to non-generalizable models and then to challengeable results. Further research and test in real-world conditions will certainly help progressing towards useful insights for both scholars and practitioners.

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Professor J.J. Chanaron (Ph.D., HDR) is Research Professor with the French National Centre for Scientific Research (CNRS) and Associate Dean Scientific Director Grenoble Ecole de Management. He has published numerous books, articles in peer-reviewed journals and conference papers in Industrial Economics, Economics of Innovation, Management of Technology and Innovation. He is Associated Professor with Henley-Reading Business School and Tongji University in Shanghai (China). He is a leading expert in the automotive industry. He is consultant to international organizations, professional organizations, OEMs and suppliers. In 2004, he has been granted the first IAMOT award for research excellence in Technology and Innovation Management.

[1] A prototype is currently under construction for the case study of clean automobile.

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Technology Management in India's Plantation Sector: Structural Infirmities Perspective

Overview of Tea & Coffee, Indigenous Machinery, Effects of Climate Change, Production Management, Quality & Safety, Trans-disciplinary R&D and Conclusion

V.G. Dhanakumar

Introduction

The plantation sector in India has experienced major changes over the years in terms of global competition, tariff structure, price volatility, innovations and technology, ownership pattern and management structure. Such changes have exposed the sector to a new operational setting. This setting is subjected to certain challenges, viz. structural infirmities, which should be appropriately addressed for the sector to perform adequately.

> A structure gives stability and standing to a system. An infirmity results in instability in the system and its environment, and all infirmities need to be addressed from time to time. Infirmities in the plantations will harm the sector and associated industries. The Indian economy is on the move and international trade in plantation commodities is very important. At this critical juncture, tea and coffee constitute important commodities and it is crucial to ensure strength of the value chain.

Thus, there is a need to evolve a policy framework to tackle the infirmities and to guide the future growth. Structural infirmities are the inherent weaknesses or limitations within the structure of the industry that inhibit performance and growth of the sector and reduce efficacy of the policy intervention. It is, therefore, imperative to address the major structural and functional rigidities faced by the industry presently to better equip it to face the challenges and become competitive in the global arena.

In discussing the relationship between technology, competitiveness and economic growth at the macro level, the OECD (1992) conclude that 'the proposition that investment in R&D and technological progress are essential for future economic growth has not yet been conclusively empirically demonstrated'. The difficulty of demonstrating this relationship is understandable as R&D is just one component of innovative activity that takes place within enterprises, albeit within the context of its

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external linkages and government policies. For an enterprise, competitiveness refers to the capacity to create and sustain cost and/or product advantages to gain or maintain strong positions in the markets for its products and a high level of profitability. In general, the advantages are based on the ability of a firm to:

(a) Successfully define its scope
(b) Manage and coordinate the core functions and operations within the enterprise as well as relationships with suppliers and customers
(c) Market demand characteristics and respond to them appropriately. In advanced technology sectors, technology and the ability to innovate are key aspects of the organizational knowledge of a firm that give it distinctive capabilities and competitive advantages

The Ministry of Commerce and Industry, GOI, has assigned the study on the Structural Infirmities in Plantation Sector (SIPS) to IIPM focusing on five critical issues such as productivity, labour issues, quality, R&D structure and competitiveness. The study has discussed elaborately the above-mentioned issues with appropriate recommendations. The report also provides an international perspective on the best practices of coffee and tea sector in comparison with competing countries.

An Overview: Coffee and Tea Sector in India

Coffee

Indian coffee production is dominated by the 'traditional' plantation areas of Karnataka, Kerala and Tamil Nadu with contributions of 71, 20.5 and 6.7% to national production, respectively. The remaining contributions are from the 'nontraditional' areas of Andhra Pradesh and Orissa as well as the northeastern states. There are mainly two types of coffee cultivated: Arabica and Robusta.

The planted area under coffee in India has grown from 0.92 lakh hectares in 1950–1951 to approximately 4 lakh hectares in 2009–2010, and the bearing area grew from 2.21 lakh hectares in 1989–1990 to 3.56 lakh hectares in 2009–2010. The planted area under coffee in the traditional and nontraditional areas during 2009–2010 is tabulated below:

It is seen from the above Table 1 that out of the 4 lakh hectares of coffee plantation, Karnataka has the major share of plantation (56.9%), followed by Kerala (21.2%) and Tamil Nadu (7.8%). Other regions contribute approximately 14% share of the cultivated land. Of the total planted area, Robusta occupies 51.5% of area and Arabica the balance.

Robusta, the less labour-intensive variety, constitutes approximately 67% of national production in 2009–2010 (Coffee Data base, Coffee Board of India, Jul–Sept, 2010). Coffee is an export-intensive sector with around 70% of the national production exported. India is the sixth largest producer of coffee (FAO STAT 2010) but contributes only around 3.53% of the world exports (Coffee Board

Table 1 Planted area by states – 2009–2010 (In hectares)

State	Arabica	%	Robusta	%	Total	% to India
Karnataka	110,023	27.5	117,317	29.4	227,340	56.9
Kerala	3,711	0.9	81,085	20.3	84,796	21.2
Tamil Nadu	25,708	6.4	5,636	1.4	31,344	7.8
Nontraditional areas	50,518	12.6	268	0.1	50,786	12.7
Northeastern region	4,035	1.0	1,382	0.3	5,417	1.4
Total (India)	193,995	48.5	205,688	51.5	399,683	100.0

Source: Database on Coffee, Coffee Board of India, Jul-Sept 2010

Table 2 Number, area and share of production under different sizes of coffee holdings in India – 2007–2008

Size of holdings (in hectares)	No. of holdings		Area under coffee		Share of production (%)
	Number	% to total	In hectares	% to total	
Small holdings					
<2	178,585	80.9	144,196	37.1	*70*
2–4	27,731	12.6	71,905	18.5	
4–10	11,800	5.3	73,642	19.0	
Subtotal	218,116	98.8	289,743	74.6	
Large holdings					
10–25	1,789	0.8	29,829	7.7	*30*
>25	920	0.4	68,623	17.7	
Subtotal	2,709	1.2	98,452	25.4	
Total (*India*)	220,825	100.0	388,195	100.0	*100*

Source: Database on Coffee, Coffee Board of India, Jul-Sept 2010

of India 2009). In the domestic market, consumption is currently growing at 5–6%, and only a very small portion is sold through auction.

Evident from Table 2, coffee production in India is predominantly a small grower's phenomenon who contributes approximately 70% of total national production. In terms of number of holdings, almost 99% of planters are under <10 ha category, and in terms of acreage, approximately 75% fall under this category. Under this category are small growers who are mostly affected by fall in yield, adverse price movements, productivity loss and other socio-economic constraints.

Coffee cultivation is shaped largely by the ecological system, and coffee is cultivated within shaded multi-crop ecosystems rich in biodiversity. Productivity is low compared to sun-grown monocultures in competing countries such as Brazil and Vietnam. Coffee production in India is vulnerable to a variety of pest and disease threats, specific to the agro-ecological conditions. The most pressing problem currently for Arabica is the white stem borer, which kills the host plant leading to significant crop losses.

Aged plantation is another important factor influencing productivity adversely. Many of the plantations have crossed the prime yielding age thereby necessitating replantation. While the need for replantation is well recognized, growers are financially incapable of meeting the replantation costs due to the recent crisis faced by the industry. With the objective of extending financial support, the Coffee Board of India has introduced Replantation Development Support. However, it is important to note that the performance of the scheme in terms of targets and achievements has been rather poor during the XI plan period. This calls for revisiting the provisions of the scheme and appropriate technology to explore avenues for improvement.

The annual labour requirement per hectare is around 400 man-days for Arabica and 300 man-days for Robusta. In the main coffee-growing areas, manual labour has been significantly short in supply. The sector is more associated with migrant seasonal labour. Labour costs constitute half of the total cost of production, which has increased by 30% over the last 5-year plan period.

An Overview: Tea

Tea industry has witnessed significant structural changes during the recent years, which include emergence of small tea growers and private bought leaf factories (BLF). In addition, there are some inherent weaknesses due to poor yield arising out of poor condition of the gardens (bushes above the economic threshold age limit), old factory setup (which affects tea quality and price realization thereof), poor garden management, ownership disputes and strained relationship between management and garden workers and labour shortage.

During the last decade, overall increase in *production* has been 134 million kg with an average annual increment of 13 million kg. Out of the total world production of around 3,750 million kg, India produces nearly 1,000 million kg, of which 200 million is exported and the rest consumed domestically. The Indian situation is different from that of the major tea-producing countries like Kenya and Sri Lanka, where nearly 95% of tea is exported (in India nearly 80% is consumed domestically). Indian tea exports today constitute only about 0.5% of total commodity exports and about 5% of total agro-export. Indian tea has been losing overseas market, and current share in global exports is around 12%.

Domestic *consumption* has increased by 166 million kg during the past decade with an average annual increment of 17 million kg. However, the growth in domestic consumption is primarily through population increase, and very little could be attributed to increase in per capita consumption.

Worldwide increasing *consumer preference* exhibits an upward movement along the value chain from loose to package to tea bags and ready to drink tea such as instant tea and tea concentrates. In addition, there is a growing awareness of consumers regarding traceability and the country of origin. Hence, value realization and margins earned would be higher from value-added exports. Exports of tea bags and instant tea constitute a very small percentage of the value-added exports. It is, therefore, necessary to explore the constraints that hinder value addition activities (viz. lack of technical infrastructure and innovation, R&D). Besides, the production in India is focused mainly on CTC due to heavy dependence on domestic demand

and the need to produce more cups a kilogramme (adverse product mix). In other words, response by the industry towards catering to the shift in consumer preferences in terms of types of tea is inadequate. Tea Board has introduced incentive scheme to induce more production of orthodox tea, which needs to be continued at least until the end of twelfth plan period.

The tea industry is associated with the livelihood concerns of a large section of its population, many of whom are indigenous tribal. The tea industry has an estimated number of 1.2 million of permanent *labour*; of these, more than 6 lakh are women workers. The industry generates income and livelihood directly and indirectly for more than 10 million. The labour force primarily belongs to deprived and disadvantaged sections of the population.

The output from the *small tea growers* (*STGs*) over the last 10 years has increased by 160 million kg from 97 to 257 million kg. The number of holdings has significantly raised. Presently, there are 1,57,000 holdings covering 1,60,000 ha. The share of small sector in all India tea production has increased from 11 to 26% over the last 10 years, mainly resulting from the new planting carried out from mid-1990 onwards. On the contrary, production of organized sector has declined by 53 million kg due to old age of bushes and manpower shortage. There is a scope for increasing the production of the small sector through higher productivity and introduction of appropriate institutional framework for advisory and extension services.

Mechanization needs to be introduced to deal with the lack of timely availability of labour and enhance labour efficacy. There is a need to provide impetus for mechanization through attractive package of incentives and subsidy to (1) induce planters to modify plantation to suit machinery, (2) train workers for proper operation of upgraded machineries and (3) ensure win-win situation for both workers and planters.

Analysis and Discussion

The analysis section discusses identified structural infirmities in coffee/tea to enhance linkages that add to the value and capability of each sector. Further, the study proposes a research programme to integrate natural science and engineering investigations with social science and policy research from the outset – what we call 'real-time technology assessment' to enhance the societal value of research-based innovation for India's plantation sector.

Trends in coffee area and productivity over the last two decades in India have been declining (decline being more significant in case of Arabica). Four-yearly compound annual growth rate (CAGR) since 1990 shows that coffee production has declined significantly during 2000–2004 due to prolonged price crisis and severe drought conditions. Four-yearly and decadal trends of productivity since 1990 have been estimated for Arabica and Robusta based on the compound annual growth rate (CAGR). Estimated CAGR during the last two decades reflects that productivity has declined, more in case of both Arabica and Robusta especially during the period of global crisis in the sector. However, continuing efforts for replantation could improve coffee productivity in the future with strategic interdisciplinary approach.

Technology for Indigenous Machinery for Different Operations Within Ergonomic Aspects of Coffee

Coffee cultivation is highly labour intensive; nearly 60–70% of the total input costs account for labour wages particularly for cultural operations like weeding, pruning, fertilizer application and harvest. In the recent years, labour unavailability and increasing labour wages have become major constraints in the plantations. The migration of labour force, especially the educated young generation, from the plantation areas to the city is the major reason for scarcity. To retain the labour force in the plantations, there is a need to develop appropriate technology with ergonomic aspects, which would reduce the drudgery involved due to estate operations and enhance labour productivity/unit area.

CCRI has already taken initiative to introduce mechanization in coffee plantations, viz. coffee mass raker, weed cutter, pit digger, bark scrubber and evaluated utility of machinery developed by the industry. Improvement of labour productivity through appropriate mechanization efforts is proposed as an important component in the EFC memorandum (X1 Plan-2007/08-2011-12) with the budget allocation of ten crores.

A status report on mechanization in Indian coffee (Raghuramulu 2010) has indicated the performance of machines developed in collaboration with the Mechanical Engineering Research Development Organization (MERDO), Chennai and various imported machinery. The study reveals that the weed cutters are able to ensure a saving of 5 man-days per acre with a cost saving of Rs. 325/- per acre. The pit diggers are capable of saving up to 50% in terms of labour and 25% in terms of costs. Similarly, some of the harvesters available in the market have shown good promise for introducing mechanical harvesting especially in Robusta coffee. This critical evaluation and field-based observations highlight that the mechanization to some extent reduces the dependence over labour with certain shortcomings like available spacing and planting design. It implicates the importance of multidisciplinary research that consists of agronomists, agri-engineering and other departments to evolve appropriate implements and machineries.

Infirmities

- Non-existence of separate R&D division for design, development and evaluation of appropriate tools and machines within ergonomic aspects for coffee estate operations
- Unsuitability of existing planting designs/terrain conditions for usage of larger machinery

Recommendations

- Design of indigenous and ergonomic dimensions of machinery for weeding and harvester by the multidisciplinary scientific team to suite the existing and proposed field design.
- It is therefore proposed to establish a separate R&D group for mechanization at CCRI within the existing PHT Division comprising of at least one agri-engineer, one scientist (postharvest technology) and 2 senior assistant specialists for providing impetus on mechanization efforts.

Technology for Tea Mechanization

Acute shortage of manpower and absenteeism are the major challenges faced by the Indian tea industry. Aspirations for better jobs and urban life have induced garden workers to switch over to alternative occupations. The NREGA 100-day scheme of the government has further aggravated this problem. Mechanization could be a solution to the problem of labour shortage. Mechanization is essential for timeliness in field operations and precision in placement of costly inputs to increase productivity and reduce unit cost of production and drudgery in farm operations.

The rigid specifications of *the tripartite Labour Agreement (1969)* between the Union, concerned state government and plantation management prevalent in *North India* mandate maintenance of a stipulated strength of workforce (as on 1.1.69 plus additions through subsequent agreements).

Since a decade, the South Indian tea industry is facing an acute shortage of workers. Data reveal that the percentage of reduction in labour strength as compared to 1999 varies between 21.4 and 56.2% with an average reduction of 25% across the region. Such reduction in labour may increase further due to non-availability of workforce in the estates.

The problem of non-availability of adequate workforce is severe during the two high cropping seasons, that is, April–May and June–September and October and November. During these high cropping seasons, about 10–11% of the total crop is harvested in a month itself. Many fields are abandoned during the high cropping seasons due to shortage of pluckers leading to crop loss. Hence, mechanization in all operations, especially harvesting, is essential. During these periods, even though harvesting is done with help of hand-operated shears resulting in a plucker productivity of 70–80 kg of green leaf/day/plucker, the estates are unable to harvest the crop completely. Indian Tea Association (ITA) during its presentation in Committee on Commodity Problems, Rome, June 2010, had emphasized on concerns over availability of labour, particularly during the peak plucking season, and resultant need to look at mechanization in tea estates.

Infirmities

- Non-availability of indigenous mechanization for harvesting and other field operations.

- Non-existence of separate R&D division for tea mechanization.
- Imported tea-harvesting machines from the developed countries are not suitable for the steep terrain of South India. Moreover, all these harvesting machines are highly expensive.

Recommendations

- Development of indigenous mechanization within ergonomic dimensions to overcome the acute shortage of labour in tea sector for pruning, plucking and spraying.
- Activities related to mechanization in tea were started by UPASI/TRF in late 1990s when labour problem started. Major activities of UPASI/TRF with respect to mechanization in tea are as follows:
  - Evaluation of machinery imported
  - Designing planting style and spacing suitable for different types of machinery
  - Development of cost-effective indigenous machinery in collaboration with other agencies
- Evaluation of plucking machines like *one-man-operated Ochiai harvester*, *two-men-operated Ochiai harvester* and *Microlete harvester* reveals that one-man-operated Ochiai harvester covers an area of *0.2–0.5 ha* and *120–137 kg G.L/ worker w*ith requirement of 3 labours to operate. Two-men-operated Ochiai harvester covers an area of *0.6–0.8 ha* and *100–220 kg G.L/worker* with requirement of 5–7 labours (hand-operated shears also should be used to complete the plucking surface). Microlete harvester is an indigenous developed harvester, but area coverage is only 0.08–0.09 ha and 80–100 kg G.L./worker.
- Different planting style and spacing are designed for different machines. However, *120×75×75-cm* spacing of Jat/done for one-man-operated Ochiai harvester (60-cm blade length) yielded 80% good leaves. Similarly, spacing of *135×75×75 cm* for two-men-operated Ochiai harvester (120-cm blade length) yields 85% good leaves.
- During 2008–2009, UPASI/TRF made a joint effort with private manufactures to develop prototypes of indigenous harvesters. However, the effort was not successful due to lack of fund and human efforts. Therefore, there is a need of separate department for mechanization in UPASI/TRF.
- Establishment of mechanization unit at TRA/TRF.

Mitigation Effects on Climate Change and Impact on Coffee

Historically, numerical prediction of impact of climate/weather events has been linked to mesoscale models run over limited areas. Recent trends however indicate that there is a demand for comprehensive global, national and regional predictions of climate. This fact suggested a new approach to derive radar information to forecast from local agro-climatic locations.

Infirmity

- Vagaries of monsoons and change in climate induce existence of severity of pests and disease and overall climatic conditions which affect production system.

Recommendations

- CCRI research should focus on development of varieties to cope with adverse climatic conditions, especially on development of suitable varieties for heavy rainfall, drought and high temperature.
- Establishment of at least one weather station in each region of Liaison Office representing agro-climatic region and linking all these stations telemetrically for short-term forecasting of weather conditions to all growers.
- These weather stations should be linked to the Forecast Systems Laboratory at CCRI for providing cumulative and accurate meteorological data by a network of global positioning system monitoring stations for effective location-specific research. Additionally, CCRI may use the service of ISRO/NRSA/Department of Earth Science, GOI, to provide agro-meteorological data to predict climatic conditions to facilitate sustainable research.
- Revisiting the critical field operations suiting climatic change.
  - Research on the potential impacts of climate change needs in-country support to enable information into language and timescales relevant for policymakers.
  - Research and selection of varieties resistant to climate change for different agro-ecological zones.
  - Specialization of CCRI personnel in fields related to climate change through collection and processing of meteorological, hydrological and pedological rainfall data and identification of coffee-climatological risk zones.

Mitigation Effects on Climate Change and Its Vulnerabilities and Impact on Tea

Findings from Tocklai Experimental Station (TES) indicate that 200-mm decrease in rainfall in tea regions of Assam is due to climate change. This decrease in rainfall was also observed both in the active growing or production season (April to October) of tea and in the normal period. On the other hand, the minimum temperate on an average has risen at many places from 1 to 1.5°C in over the last 90 years (www.newkerala.com/news/fullnews.htm).

Estimates made at TES, Jorhat, also suggest that the carbon dioxide content is increasing at a rate of 1.5 ppm per year. Elevated carbon dioxide is known to influence C3 plants like tea favourably, and it is known that the photosynthesis increases proportionately with increase in light intensity and elevated carbon dioxide. However, the exact level of light intensity and temperature responsible for inducing higher photosynthetic activity is still unknown in tea. It is also worthwhile to mention that elevated carbon dioxide in the absence of shade in tea fields coupled with potential UVB radiation may impact the tea yields negatively. However, it is a researchable issue and needs thorough investigation, because a whole lot of weather parameters impact yield.

Long-term rainfall records suggest that the average annual rainfall is receding alarmingly. It appears that in the last more than 92 years, more than 200 mm of annual average rainfall has been lost. This decrease in rainfall is also observed in both the active growing/production season (April to October) of tea and in the monsoonal period. But the decrease in rainfall is little in the period from October to April. Since a tea plant stays in the field for more than 50 years, hence decreasing rainfall will certainly produce some stress on long-term basis, because it is the same plant that is experiencing water stress.

Infirmities

- Lack of suitable technologies/operations for the changes in the timing of natural processes like flowering, growing seasons, irrigation, planting, pest and disease
- Lack of facilities to carry out research on impact of elevated carbon dioxide and temperature

Recommendations

- Establishment of climate research laboratory.
- Revisiting package of practices with regard to field activities, viz. rationalization of fertilizer application, alternate control mechanism for pests and disease, pruning, plucking and manuring, to help tea industry for the overall development of the sector

Formulation of Eco-Friendly Plant Protection Measures and Management

Pesticide residues in tea cause serious concern globally. In recent years, there has been a greater dependence on the use of pesticides (7.35–16.75 kg/ha) with little importance on other safe control methods for the management of tea pests. Due to this practice, the tea pests showed a higher tolerance/resistance status. The growing concern about the pesticide residue in made tea, its toxicity hazards to consumers, the spiralling cost of pesticides and their application has necessitated a suitable planning which will ensure a safe, economic as well as effective pest management in tea (http://www.ncbi.nlm.nih.gov/pubmed/19297972). Due to continuous use of synthetic pesticide during last two decades, for example, the tea mosquito bug *Helopeltis theivora* has become the most destructive sucking pest in Northeast India and indiscriminate usage which affects the quality of tea (www.himalnews.wordpress.com). Therefore, usage of most of commonly used pesticides is restricted, and only a few pesticides are allowed for the management of pests and diseases in tea. Continuous use of synthetic chemicals for the control led to development of resistance in targeted organisms. Besides, overuse of chemical fertilizer affected the soil health and soil enzymes. Moreover, in tea only chemical weed control measures are being practised for the last two to three decades due to cost-effectiveness and requirement of less labour force.

Infirmities

- Higher pesticide residue in made tea due to overdose of pesticides, weedicides and chemical fertilizers
- Lack of adoption of GAP to minimize pesticide residue at field level

Recommendations

Development of integrated pest and disease management (IPDM) strategies with usage of:

- Biological enhancement of efficacy of biological control agents, including entomopathogens, development of kairomone and pheromone traps and microbial biocontrol agents
- Development of biological and botanical weed control techniques
- Integrated nutrient management (INM) by utilizing bio-fertilizer

Technology for Coffee Quality Improvement (Organoleptic)

The intrinsic quality of coffee is influenced by the plant material, cultural practices and processing techniques both at the estate and curing works. Delayed pulping, over-fermentation, improper washing, storing of coffee near pesticides, packaging of coffee in inferior quality gunny bags and improper drying cause off-taste in the coffee which can be evaluated during cupping.

A prescribed manner of brewing and a specific series of steps lead to a complete sensory evaluation through olfaction, gestation and mouthfeel sensation, because cupping technology is usually associated with economic purpose such as buying or blending of coffee.

Quality assurance systems (QAS) already exist and are becoming compulsory at all levels of coffee production system. It is likely to become as an essential component at the grower level over the next few years. QAS is likely to be an industry-wide requirement regardless of the level of development of the sector. It would incorporate chemical usage and be a requirement of all industries making funding applications for research and development. However, there is a need to collect, collate and modify where necessary information from other production areas and systems. Certification systems for roasters are already in place and are internationally recognized. There is a need for whole-chain management of coffee quality. Even the assistant preparing the cup of coffee can have a crucial effect on consumer satisfaction. It is therefore proposed to strengthen the quality control unit with appropriate technology for organoleptic evaluation.

Infirmities

- Restricted focus on quality aspect of development with special reference to intrinsic quality of coffee at the estate level
- Lack of adoption of GAP and GMP to ensure quality of coffee
- Limited R&D activities on quality assurance system with special reference to coffee quality profiles including safety aspects

Recommendations

- Research on *organoleptic*[1] characteristic for specialty coffee to improve flavour, taste, aroma, mouthfeel, colour, long-lasting taste and other analogous factor of cup quality
- Effects of altitude, shade, fertilization and processing factors which influence the organoleptic characteristics of cup quality
- Diffusion of information on GAP, GMP and community processing
- R&D thrust areas on quality assurance system, including the relationships between coffee composition and sensory properties and relationships between sensory properties and consumer perceptions of quality and accessibility

Research on Quality and Safety-Related Issues in Tea

Quality and safety (Qualsafe) in plantation commodity and food sector through application of HACCP/ISO 22000 and GLOBALGAP principles of sanitary and phytosanitary (SPS) agreements of WTO are essential for competitiveness, equally in case of both the producers/manufacturers and exporters, in this era of food security regime. It is particularly important to understand the application of these principles within SQF-SCM perspectives in tea sector value chain to delight customer. Principles of food hygiene are a systematic approach to the identification, assessment and control of hazards in tea sector.

The SPS aspects of HACCP/ISO22000 are an abbreviation for hazard analysis and critical control point. It is the most effective management system of maximizing product safety and quality and cost-effective system. It targets system to critical areas of processing and reducing the risk of manufacturing and selling unsafe products. Critical control points are the steps in manufacture and value addition where control is essential to guarantee that potential hazards do not become manifest as actual hazards. A critical control point (CCP) of HACCP system is a location, a practice, a procedure or a process, which, if not controlled, could result in an unacceptable safety risk in made tea.

Infirmities

- Different MRL levels for same chemicals in different countries
- Lack of documentation on data related to pesticide residue

[1] ISO-1992 denotes the attributes of a product that are perceptible by sense of organs. It is the science of sensory analysis, measuring flavour.

Recommendations

- To formulate new projects for fixation of MRL for national and international standards in collaboration with CFTRI, NABL, PFA intergovernmental group and the Ministry of Health, GOI
- To set up a state-of-art residue laboratory with an outlay during XII 5-year plan

R&D activities on quality assurance system including safety aspects of tea to be undertaken with special reference to the following:

1. Research for compiling need-based quality assurance system in identification of CCP, CL and corrective action across tea value chain with reference to HACCP/ISO 22000 to meet WTO: SPS/TBT requirements
2. Industry-driven research to identify 13 critical points with special reference to tea to meet the criteria of GLOBALGAP which incorporates IPM and ICM practices within the framework of sustainable tea production for global harmonization

Need for Trans-disciplinary Development

Policy programme implementation is essentially dependent upon interagency (or) multi-R&D/extension/promotion unit collaboration and resource sharing, representing commitment to something larger than the single-focused organizational goals and objectives and a shift to enter into partnership with other commodity boards to achieve shared goals and visions and respond to mutual interest and obligations.

From a managerial perspective, commodity boards inter-organization collaboration is often encouraged on the basis that it delivers greater productivity than the alternatives. It is proposed to create linkage among four vital commodity boards as part of restructuring exercise to sustain focus on collective development through mutual help.

Infirmity

- Lack of specific occurrence of disciplinary crossovers: *trans-disciplinary*[2] realization of commodity boards activities across plantation research institutes that addresses societal problems

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[2] The *trans-disciplinary approach* is a framework for allowing members of an R&D team to contribute knowledge and skills, collaborate with other members and collectively determine the services that most would benefit the commodity research and development. 'This approach integrates the developmental needs across the major research domains' and 'involves a greater degree of collaboration than other service delivery models'. A trans-disciplinary approach requires the R&D team members to share roles and systematically cross inter-institutional discipline boundaries. The primary purpose of this approach is to pool and integrate the expertise of R&D team members so that more efficient and comprehensive assessment and intervention services may be provided. The communication style in this type of team involves continuous give-and-take between all members on a regular, planned basis. Professionals from different disciplines research, teach, learn and work together to accomplish a common set of R&D intervention goals for commodity. The role differentiation between disciplines is defined by the needs of the situation rather than by discipline-specific characteristics. Assessment, intervention and evaluation are carried out jointly by designated members of the team.

Recommendations

- The proposed plantation coordination committee (PCC) serves as an autonomous organization under the Department of Commerce (DOC), Ministry of Commerce and Industry, Government of India. With four central plantation research institutes and its associated regional and substations spread across the country, PCC network (Fig. 1) shall be one of the largest national plantation research and extension systems in the world.

Retention and Turnover of Scientists

Building and maintaining the magnetism is necessary to attract and retain scientists of CCRI for dynamic and strategic R&D planning. R&D organizations face major challenges when they consider the increasing difficulty of finding and retaining talented scientists, a younger group with different attitudes about work and a growing population of senior scientists heading towards retirement. A recent study shows 85% of HR executives state the single greatest challenge they have in managing the scientists.

The retention and turnover of CCRI personnel reveal that initiative comes at a time when many strategic and futuristic programmes of CCRI are getting delayed because of manpower crunch and failure of the organization to retain scientists. 'The high attrition rate especially at the entry level is a serious problem affecting CCRI strategic progrmames, which is around 24% has become a key factor affecting its performance'.

Infirmities

- Non-availability of required scientific and technical personnel
- Delay in implementation of 6th CPC at par with ICAR/CSIR
- Delay in recruitments and implementation of appropriate career improvement policies from time to time as done in other research organizations like ICAR

Recommendations

- Recruitment of scientists/technical officers to meet basic requirement of Central Coffee Research Institute with appropriate scales at par with ICAR rank and scale.
- Appointment of new scientific personnel with and career-promising improvement, opportunities to young scientists may reduce high attrition rate and enhance performance of R&D within CCRI.

International Competitiveness

Coffee is an important commodity and a popular beverage. Over 2.25 billion cups of coffee are consumed in the world every day. Most of the world coffee production takes place in countries such as Brazil, Colombia and Vietnam. Coffee consumption

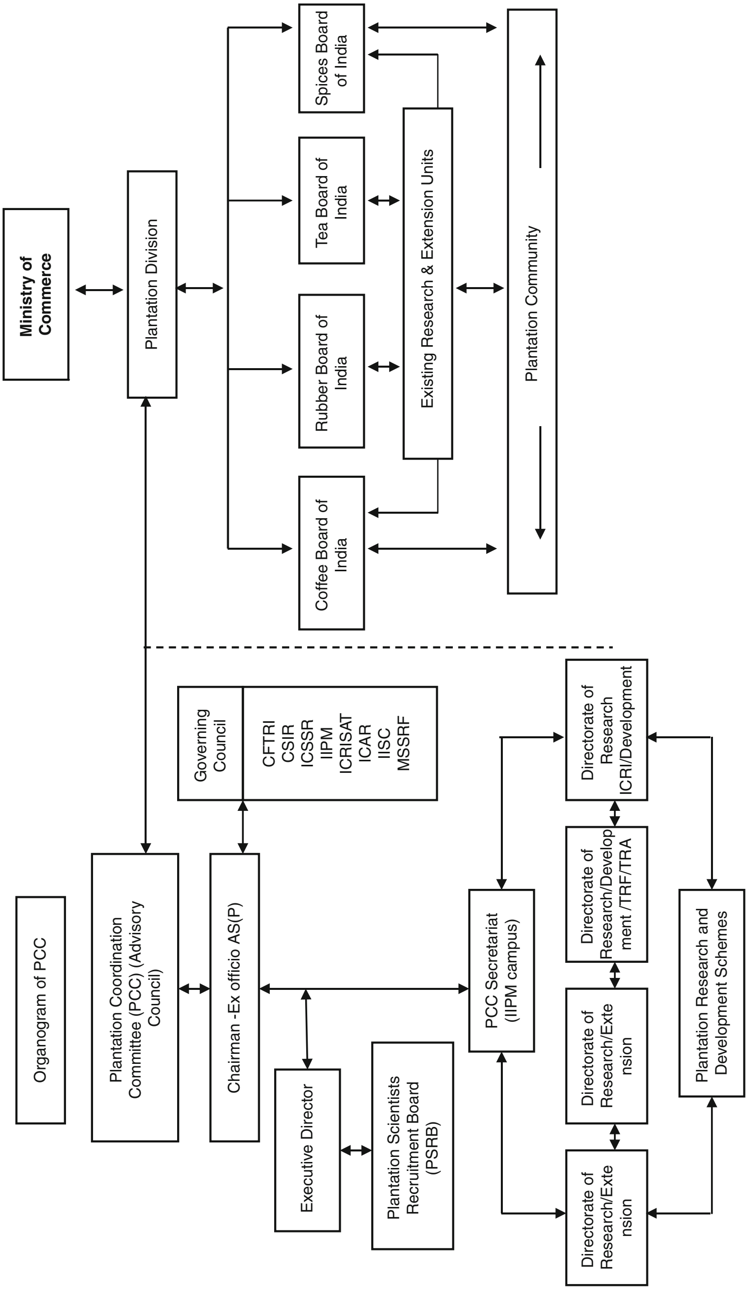

Fig. 1 Proposed organizational structure for PCC of Commodity Boards of India, Ministry of Commerce and Industry

Table 3 Comparative profile of countries

Basic indicators	Brazil	Colombia	India	Vietnam
Total production (000 bags)	39,470	8,098	4,827 (4)	18,200
Domestic consumption (000 bags)	18,390	1,400	1,573 (3)	1,583
Productivity (kg/ha)	1,259	940	766 (4)	2,011
Per capita consumption (kg)	5.7	1.84	0.08 (4)	1.08
Export of green coffee (60-kg bags)	27,366,040	7,258,326	2,092,950 (4)	17,043,720
Export of processed coffee (60-kg bags GBE)	2,973,118	635,589	1,028,890 (2)	8,014
Exports as a percentage of production (%)	53.4	82.7	67.4 (3)	91.3
Value of exports of all forms of coffee (million US$)	4269.55	1710.03	375.53 (4)	1491.64

Source: ICO and FAOSTAT (2008); Figures in parentheses denote India's position in comparison with top coffee producing countries, viz. Brazil and Colombia (Arabica) and Vietnam (Robusta)

is concentrated primarily in Western Europe and North America, though Eastern Europe and parts of Asia (especially China) exhibit an increasing trend. The report is based on secondary sources published during 2002–2011. A basic comparative profile of these countries is presented in Table 3.

Evidently, coffee is an export-intensive sector in all these countries. However, it is observed that the proportion of processed coffee exported is significantly high (rank: 2) in India compared to other competitors. India occupies a much lower rank (rank: 4) in terms of earnings from exports. Much of India's production is destined for Italy and countries in the former Soviet Bloc. Arguably, the potential for higher value realization is limited as exports to Italy take the form of just filler beans and the Indian coffee quality is not adequately rewarded. Similarly, the portion of exports to the former Soviet Bloc is converted to instant coffee, with limited export value realization compared to other countries. India's share in the premium-priced Arabica specialty market continues to be very limited at around 5%. This requires a closer attention as competing countries enhance their shares in techno-managerial quality conscious to markets and serve the growing domestic specialty sectors. A comparative assessment of relevant parameters is presented in Table 4.

Conclusion

Studies and assessments on the structural infirmities in plantation and socio-economic aspects of the planters are a prerequisite for the success of plantation sector. Design of indigenous and ergonomic dimensions of machinery by the multidisciplinary scientific team to suite the existing and proposed field design, to overcome the problem of acute labour shortage, is recommended. It is therefore suggested to establish a separate R&D group for mechanization for providing impetus on mechanization efforts.

Table 4 Comparative assessment of relevant parameters

Indicators	Brazil	Colombia	India	Vietnam
Production	Open-sun monoculture	Open-shade monoculture	Shade-grown mixed crop	Open monoculture
Practice	Intensive cultivation	Intensive cultivation	Optimum density/inputs	Intensive cultivation/high usage of inputs
Rainfall/irrigation	Well-distributed rainfall	Well-distributed rainfall	Seasonal rain/long dry spell	Basin irrigated
Soil	Fertile volcanic soil/flat to gentle slope terrain	Fertile volcanic soil	Lateritic to clay loam soil	Fertile volcanic soil
Labour issues	High labour costs	High labour costs	Comparatively lower costs/ non-availability	Comparatively lower costs
Status of mechanization	Fully mechanized farms (miniaturization)	Limited mechanization	Difficult to mechanize	Mostly manual labour (family)
R&D structure	Brazilian Coffee Research and Development Consortium	CENICAFE	Coffee Board of India CCRI	VICOFA initiatives
	Embrapa	Federacafe	Extension network	WASI

It is proposed to formulate new projects for fixation of MRL for national and international standards. Research may be undertaken for compiling need-based quality assurance system in identification of CCP, CL and corrective action across tea value chain with reference to HACCP/ISO 22000, GLOBALGAP, ISO 9000 and SQF after successful implementation of GHP, GAP and GMP to meet WTO: SPS/TBT requirements.

In order to study on mitigation of effects of climatic conditions, research should focus on development of varieties to cope with adverse climatic conditions, especially on development of suitable varieties for heavy rainfall, drought and high temperature. The weather stations should be linked to the 'Forecast Systems Laboratory' for 'global positioning system'. It is necessary to revisit production practices with regard to field activities (viz. rationalization of fertilizer application, alternate control mechanism for pests and disease, pruning, plucking, manuring).

Research on Coffee Quality Improvement (CQI), focus on organoleptic implies characteristic for specialty coffee to improve flavour, taste, aroma, mouthfeel, colour, long-lasting taste and other analogous factor of cup quality is recommended.

It is recommended that formation of plantation coordination committee (PCC) across all commodity boards with broader objectives of discussing common issues across all commodity sectors, on a common forum.

Building and maintaining the magnetism is necessary to attract and retain scientists for dynamic and strategic R&D planning. R&D organizations face major challenges when they consider the increasing difficulty of finding and retaining talented scientists, a younger group with different attitudes about work and a growing population of senior scientists heading towards retirement.

In the face of serious competition from competing countries in terms of cost competitiveness, India needs to identify new potential markets in Asia and Eastern Europe. At the same time, India has to enhance its presence in the high-quality specialty markets, which has been insignificant thus far. It requires investments in the development and orientation of differentiated quality with 'country of origin (COO)' tag to remain competitive.

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FNC, Columbia
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Vietnam Coffee and Cocoa Association (VICOFA)
Western Highlands Agriculture and Forestry Science Institute (WASI), Vietnam.
Wikipedia

Good Urban Governance and Smart Technologies: A German City as a Best Practice Case of E-Government

Joerg Himmelreich

"*E-government is about government.*"

(Lenk 2005)

Smart technology in the following context is understood as the application of Information and Communication Technologies (ICT). ICT have already changed governance policies in the past and will even do more so in the future. This change is taking place in many regards, which cannot be explored here in more detail, but one consequence of the increasingly intensive penetration of the daily and political urban life by ICT is a growing global competition between cities and megacities.

As progressing urbanisation is an unavoidable consequence of progressing globalisation, the number and size of cities grow mainly in Asia. Because of the growing number of cities, they are going to compete globally for attracting the smartest people, the smartest businesses and the smartest urban governance model.

ICT drives globalisation and confronts cities and megacities worldwide with more and more comparable problems in spite of all the historical, cultural, social and economic differences that influence the living conditions of each and every city. Quickly, cities of India will face more and more comparable challenges for the urban governance (health service, education, traffic, urban planning, public services and utilities) like cities in Germany – as strange as this remark may sound today.

Without doubt, smart technologies are changing urban political governance. During an early euphoria in Germany about what smart technologies all can help to improve, sometimes political governance became a hostage of ITC business and lobby groups that walked around the country to predict management and governance problems that allegedly only could be solved by the newest version of a specific ITC application. Later it turned sometimes out that either the predicted problem did not occur or the marketed and sold ITC application was unable to solve it.

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In both alternatives, a waste of misled multimillion-euro investments had been the consequence. Smart technologies are driving political federal, state and urban governance. Today there is a broad understanding on the German political federal level, that political urban governance has to drive the use and application of smart technologies. Smart technologies can only deliver the means to improve urban governance; it cannot substitute bad governance. Governance deficits can only be solved by the governance itself (of the people, of the political parties and of the other stakeholders of the political governments). Therefore, E-government is about government.

Electronic government means the settlement of management processes in the context of public governance and administration by the application of Information and Communication Technologies (Reinermann 2003, pp 381–440 (381)). It comprises the entire public sector, consisting of public administrations, public associations and public business enterprises on all levels. On the one hand E-government addresses the internal management of the administration in order to improve the internal administrative procedures by the application of modern ICT. In the context to improve the internal service quality, E-government aims to accelerate the settlement of the administrative file, to reduce costs, to improve the cooperation between various administration departments and sector by a free flow of data and information and to reduce and to simplify complex internal procedures. On the other hand, E-government looks at the external communications partners of public administration. It concerns communication processes with other government sectors, (government to government – G2G), with private business companies (government to business – G2B) and to non-profit organisations (government to non-profit – G2N) and (government to citizens – G2C) (von Lucke and Reinermann 2000, p 1). Meanwhile, a broad sector in academic sciences discusses and analyses the political and legal implications of E-government for the public governance and administration that cannot be discussed here.

The potential of the ITC applications in government administrations was recognised by the Federal German Government, too, to make the administration more efficient and more transparent and to improve the participation of citizens in the administration process and in the government, too.

In order to regain the supremacy about the fast modernisation processes of ICT and to lead it to the benefit of an improvement of governance and administration, the Federal German Government sets up an E-Government Platform ("IT-Planungsrat"). Representatives of all government levels (federal, state and municipal) participated in it to launch an E-government strategy (E-Government Strategy 2012).[1] This all-inclusive top-down approach guaranteed a harmonised common approach with the chance of complete interconnection and data exchange where legally possible and to avoid separate individual ICT solutions by single municipalities.

The following contribution describes how the German city of Delmenhorst improved its urban governance by smart technologies. This small German town with 80,000 inhabitants was chosen as the best practice case, because many challenges by the application of smart technologies for urban governance are more

[1]E-Government strategy, launched by the IT-Planungsrat, http://www.it-planungsrat.de/DE/Strategie/negs_node.html, seen at May 14, E-Government strategy 2012.

easy to demonstrate than in a complex governance structure of a city with millions of inhabitants.

Before this city analysis, the particularities of German urban governance have to be briefly presented and contrasted with the Indian urban governance model in Bangalore.[2] Besides this, the E-master plan of the German state of Lower Saxony has to be described as Delmenhorst is located in this state. After all, some lessons learned from the best practice case of Delmenhorst may be drawn even for an Indian megacity like Bangalore in spite of the fundamentally different political, cultural, social and economic environment.

The German Urban Governance Model

German cities enjoy a particular right of municipal autonomy, guaranteed in and by the constitution. Historically this constitutional guarantee of municipal autonomy is rooted in the administrative reforms of the Prussian political reformers Baron Stein and Lord Hardenberg (Püttner 2008, pp 1141–1173 (1142)). In 1808 both recalled the passed autonomy of German mediaeval towns to improve the citizen participation in public affairs and to engage the Prussian citizens against Napoleon's military invasion and occupation in Russia. These reforms helped to contribute to the foundation of a long German constitutional and administrative tradition of municipal autonomy – by the way, in stark contrast to the British model of urban governance in Great Britain and the Commonwealth. Those reforms were implemented in the year of 1808 in the Prussian City Charter ("Preußische Städteordnung" from 1808). During an era, when at the same time parallel to the process of industrialisation this one of urbanisation took off, these municipal reforms proved to be more and more helpful to respond to the challenges of urbanisation just until 1980 – even during the periods of Prussian and German monarchies.

"The law has to be granted to all municipalities and to govern all matters of local community within the legal framework by themselves," Article 28 Para 2 of the German constitution reads. In application of this constitutional law of municipal self-governance, the voters among 80,000 inhabitants of Delmenhorst elect a mayor, who is in office for 8 years, and 42 other members of the municipal council for 5 years each. The mayor is at the same time head of the municipal administration. As the city of Delmenhorst is not part of the community of other districts, the mayor is directly responsible for all other local matters to the responsible minister of the state government of the state of Lower Saxony.

As head of the administration, he exclusively recruits the civil servants for the municipal administration. As to the urban planning, the city of Delmenhorst is exclusively responsible for the use of land within the territory of the city as well as for the planning and maintenance of local streets within this territory. Regarding the planning of state and federal highways, this city has to be included in the planning processes as well.

[2] The author is aware that there is not one similar urban governance model for all cities in India, but at least three different ones in different States.

The city has to administer its own financial resources. The financial revenues for municipalities are granted by Art. 106 of the German constitution. The city receives 15% of the federal income taxes, 2.2% of the federal VAT and the entire business tax for business licences granted by the city. For local services, cities are able to demand their own fees (like for the local public swimming pool, local bus transport, etc.). The planning of land and the budget have to be approved by the city council. In contrast to the overlapping responsibilities of the municipal administration of Bangalore, the administrative responsibilities in a German city are clear-cut and strongly separated (office for businesses licences, office for construction permissions, etc.) and regulated by law. If it is about municipal services, shortcomings can be claimed by the citizens at the courts.

In comparison with the mayor of the megacity of Bangalore with 8.4 million inhabitants, the mayor of Delmenhorst with 80,000 inhabitants is a political heavyweight. The mayor of Bangalore is elected just for 1 year by the council and has little responsibilities, no autonomous income resources for the city, no exclusive planning authority and is surrounded by the Government of Karnataka and its administration consisting of civil servants he has not appointed.

This constitutionally and institutionally weak governance of Bangalore cannot be changed and improved by smart technologies. It is a government problem. That makes the application and introduction of smart technologies for the urban government of Bangalore even more complicated and complex.

E-Government Master Plan of Lower Saxony

The E-Government Masterplan of Lower Saxony of 2010 updated the E-government master plan from 2005[3] to implement the federal E-government strategy for the improvement of transparency and efficiency of the German adminstration and to improve thereby the quality of the public services and the administration service for the citizens, and the information and participation of citizens in the local administrative affairs.

The focus of the masterplan is foremost on the improvement of the quality of services for the citizens to enable them to receive an easy, clear and understandable online access to all services of the state and municipal administration. This project "Citizen and Business Services" (CBS) pursues to connect all municipal administrations with the online services of Lower Saxony and to update the services regularly. Other objectives are:

- All forms of the administration are put online and shall be downloaded and printed out.
- One service portal service point "www.service.niedersachsen.de" directs the citizen to all information, forms of online services.

[3] Cf. http://www.mi.niedersachsen.de/portal/live.php?navigation_id=14926&_psmand=33, (May 14, 2012) leads tot he E-masterplans of 2010 and 2005 and to the e-government strategy of Lower Saxony.

- If the citizen is once registered and identified in a central service portal online, he shall be able to sign electronically all forms, applications and online services to the extent legally and technically possible.
- There will be implemented a tailor made online service for the set-up of companies and business resources.

For the improvement of the efficiency and transparency of the administration in Lower Saxony the exchange of data, information and files among many different local and State administrtation and within each administration itself shall exclusively be sent electronically.The use of paper shall become an exception. There are until today concerns as to the security of the sending of electronic data files. Regarding the unification of the central personal management system for the whole state it has to be stated that administrative procedures that have to include safe payments and procurements are lacking still today the required ultimate technological security standards.

Smart Technologies and E-Governance in Delmenhorst[4]

The present status of the implementation of these objectives of the Lower Saxony Masterplan in Delmenhorst looks like the following: as to the electronic data exchange between the administrations of the municipality and the State of Lower Saxony, the city of Delmenhorst is completely connected with and included in the data exchange system of the State of Lower Saxony. The State of Lower Saxony is still going to develop various services like, for instance, the payment service for administrative services. At which point of time, this service can be offered locally, too, cannot yet be predicted realistically. Up to now, there is still not yet one municipal public service established which can exclusively be settled electronically. Since August 2011, the city of Delmenhorst has a completely newly restored Internet presence. Via the website "www.delmenhorst.de," local citizens can find all administrative services of the municipality and of the state as well as of the responsible civil servant to talk to. Besides this, Delmenhorst is electronically connected closely with some federal administrations as well. For the issuance of an ID card, for instance, the local citizen office sends all personal data via the State of Lower Saxony to the federal central registration office for IDs. The citizen immediately receives the new ID at every local citizen office. The city of Delmenhorst has its own server. Every civil officer is connected to it. For every civil servant, basic ICT knowledge is a requirement for the qualification for the job.

As to the improvement of information about the municipal administration and services of Delmenhorst for the citizens, the efficiency and transparency of the administration and thus of urban governance are considerably progressing. The saving of time and administrative salaries is obvious, but difficult to measure by exact figures. Fundamental innovations like the entire completion of the administration

[4] The author owes many thanks to Patrick de La Lanne, the mayor of Delmenhorst, for his frankness to give all relevant information about the status of the implementation of E-government in the municipal administration in the interview on May 13, 2012 in Delmenhorst.

procedures for granting licences, social aids, etc. and the completion of the EU payment service have still to be finalised. In both these areas technologically safe solutions that meet all legal requirements are still in demand.

Even more distant in the future is the development of the complex of electronic political voting. As Delmenhorst has to deal with a high number of foreign migrants from Turkey and Eastern Europe (around 60% of the inhabitants), around 45% of the citizens have still not even a basic ICT knowledge to use the online services of their city.

Conclusion

The fundamental precondition for the use of the entire potential of smart technologies and applications for the urban governance in Bangalore is to improve the urban governance itself. The 74th Amendment of the Indian Constitution, many Indian innovative initiatives,[5] commissions[6] and high task force reports[7] already demand and suggest that the federal states like that of Karnataka have to grant the right of municipal autonomy and self-government to their cities like that of Bangalore.

India has the longest written constitution in the world. In 1947, it was influenced by the British constitutional thinking that didn't acknowledge the advantages of municipal autonomy apart from London and Delhi. That is why the UK today sees comparable political struggles to grant a larger municipal autonomy and an institutionally strong mayor to British cities to respond to the challenges of urbanisation on the local level.[8] This British constitutional heritage of a firmly centralised federal governance helped India early after Independence to establish one united state on the South Asian continent at the first time in history. But today, all major problems of urbanisation for Indian (mega)cities (traffic, health, education, public utilities, urban planning) can only be solved by a stronger degree of municipal autonomy. It is time for India and her states to liberalise themselves from the last of British colonisation. The German model of municipal and constitutionally guaranteed autonomy is not entirely applicable to an Indian urban governance model for Bangalore, but it might offer some orientation.

Only then political governance can drive smart technologies and the modernisation of their applications instead of becoming their hostage. The potential for

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[5] Compare: Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Dec. 3rd, 2005.

[6] Government of India, Second Administrative Reforms Commission, Sixth Report, Local Governance, October 2007, pp 198–220.

[7] The High Powered Expert Committee (HPEC) for Estimating the Investment Requirements for Urban Infrastructure Services, March 2011, pp 89–116; Report of the Expert Committee, Governance in the Bangalore Metropolitan Region and Bruhat Bangalore Mahanagara Palike ("Kasturirangan Report"), March 2008, pp 23–29.

[8] "Elf englische Städte sollen einen Bürgermeister erhalten" (Eleven English cities shall get a mayor), Neue Zürcher Zeitung, May 3, 2012.

smart technologies in the urban governance is huge. Improving the efficiency and transparency of the municipal administration, various deadlocks in the urban governance can be overcome. It requires a sufficient smart technology education of every civil officer and of course of every citizen of Bangalore. This education could be particularly helpful for the socially weak in Bangalore. But for the running, heading and managing of such a smart technology revolution in urban governance, a politically and institutionally strong mayor in Bangalore is needed. In comparison with the mayor of a little German 80,000 inhabitants town of Delmenhorst, who is elected for 8 years and the only head of the municipal administration with autonomous, legally guaranteed revenue resources, the one-year mayor of the megacity of Bangalore looks institutionally rather weak because of his constitutionally limited authorities ("Just a pawn in the political game?", 2012) – unable to use the unlimited knowledge and technical expertise of smart technologies, available only in Bangalore.

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An Overview on Technology Nurturing and Incubation from a Life Science Perspective

Mohan Sridhar, Nandini Arunkumar, Shreyas Burji, and Taslimarif Saiyed

Introduction

Technology in Life Sciences

Traditionally, technology in life sciences is defined as the application of scientific principles and knowledge to solve a problem or perform a specific function. Of the potential new technologies available at any one time, only a few are developed and become widely implemented. In this way, technology is shaped by society, by consumer choice. Yet it could also be argued that technology shapes society – the automobile technology, a simple example, has shaped our way of life as well as the environment around us.

Bioinnovation

Innovation is the translation of novel ideas and skills to produce new technologies, products, processes and services that improve economic and social prosperity. In biotechnology, the innovation process begins with a scientific discovery in the laboratory followed up by development of this promising discovery into a technology or product that has commercial value to the market as a finished product (Hansen and Birkinshaw 2007):

Step 1: Research-driven organizations such as those in academia are mandated to expand the limits of scientific knowledge and are in the best position to make new scientific discoveries – either by accident or by systematic study of existing problems.

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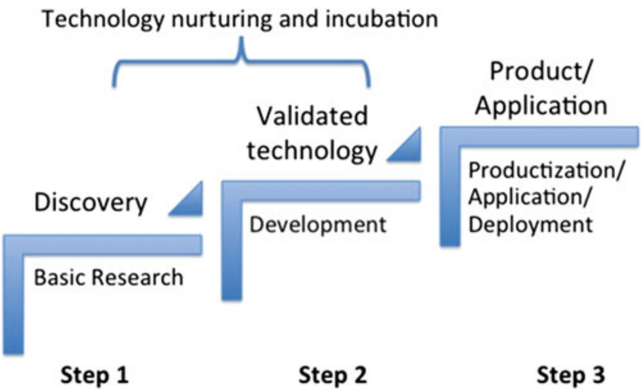

Fig. 1 The above figure depicts a typical lifescience innovation pathway. *Step 1* represents basic research which provides discovery. *Step 2* represents development work giving rise to validated technology, and *Step 3* shows application work which generates product or service from the particular discovery. The overlap between *Step 1* and *Step 2* suggests a vital step where the discovery needs to be carefully developed into a validated technology. This overlap or phase of the lifecycle is often referred to as the technology nurturing and incubation phase

Step 2: These discoveries enter into validation process through proof of concept studies and after intellectual property protection has been sought, almost exclusively become the domain of big players in the industry like pharma or biotech companies to further develop and commercialize.

Step 3: Productization or application of validated technology requires not only technical capabilities but also substantial investment, regulatory approvals, market strategy, etc. In terms of drug discovery, it takes at least 15 years (Time magazine – http://www.time.com/time/magazine/article/0,9171,404241,00.html) to develop drug candidates, for instance, and to even establish a platform technology requires a significant input of time, not to mention the capital intensive nature of both these activities. Hence, big biotech and pharma organizations have this scientific and financial muscle to work through the layers of regulatory needs, clinical trials and marketing that is necessary to take a product into the market (Fig. 1).

Why Is It Important to Nurture Technology?

In order to progress from Step 1 to Step 2 of this depicted life science innovation pathway, researchers require knowledge of business strategy and a thorough knowledge of where their discovery can be applied in society. Many researchers who go on to become entrepreneurs, although they have an exciting discovery, do not have very sound understanding of possible applications of their discovery, competitive landscape, IP issues, regulatory requirements, investment and funding access, market awareness, much needed laboratory infrastructure for development or business expertise to be able to realize the potential of their discovery.

Ways to Nurture Innovation

Scientific entrepreneurs have a wealth of scientific knowledge and deep understanding of the biological systems that they work on. Whilst this makes them invaluable assets to a start-up, they need support and assistance in translating their scientific research into economic activity.

This support comes in different forms and from different sources:

1. Governmental support – grants, funding schemes and policy
   For example, in India, the Department of Biotechnology through the Small Business Innovation Research Initiative (SBIRI) grants, Biotechnology Industry Research Assistance Programme (BIRAP) and Biotechnology Industry Partnership Programme (BIPP) aims to foster innovation in research and development in biotechnology in India.
   In the USA, there are a number of funding schemes from federal and state governments. The most recognized are the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) schemes. In Europe, there are various schemes such as the Grant for Research and Development scheme introduced recently in 2011 and the Wakefield Grant for Incubation. Also recently, the UK government has opened up funds of 180 m euros to support new biotech and healthcare companies through an initiative called the Biomedical Catalyst (http://www.sscn.co.uk/PublicAccess/News/tabid/58/default.aspx?article=The+BioMedical+Catalyst++Competition+Open%20792).
2. Academic institutional support – scientific talent and infrastructure
   Academic and research institutes have an enviable scientific talent working on diverse scientific problems. They also have access to the wide range of equipment and technology that is needed for scientific research and discovery. A new start-up can collaborate with investigators in academia to tap both the scientific expertise and infrastructure that are available to them. This support is common across major research clusters around the world such as Oxford and Cambridge in the UK and Boston and MIT in the USA.
3. Business/technology incubators
   Business/technology incubators attempt and are structured to provide a comprehensive nurturing and supportive environment to young start-ups. This nurturing environment provides all the support needed for the start-up including scientific, business and legal support to help guide researchers-turned-entrepreneurs and where embryonic ideas can become the basis for tomorrow's great technologies or products.

Business/Technology Incubation

Business/technology incubators are designed to support the successful development of entrepreneurial companies through an array of business as well as technical support resources and services, developed and orchestrated by incubator management.

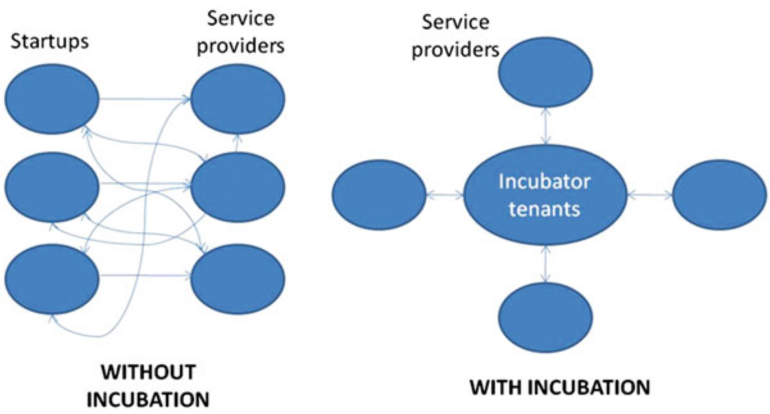

Fig. 2 Comparison between interaction of service providers and companies with and without incubation. The figure describes how incubation could help a start-up with streamlining interactions with service providers instead of complex network interactions. Also, the same is true in terms of start-up interaction with funding, regulatory, legal and technical players, which is substantially streamlined through an incubation process

These incubators promote a culture where science/technology and business can mix to promote innovation (Wanklin 2002).

How Incubators Help to Nurture Technology

Firstly, running a successful incubator involves identifying exciting discoveries led by entrepreneurial researchers. The shortlisted candidates for tenancy are then screened based on set selection criteria. Those selected entrepreneurs or small companies are provided with a number of services and given access to space and infrastructure to develop on their discoveries. Some of the value-added services provided by incubators include business mentoring, networking activities for tenant companies, marketing assistance, help with accounting/financial management, links to strategic partners, access to angel investors or venture capital, comprehensive business training programmes, technology commercialization assistance, help with regulatory compliance and intellectual property management assistance (Knopp and National Business Incubation Association (NBIA) 2007).

Rather than individual start-up companies seeking out service providers on their own, incubators provide a centralized location where all tenant companies can not only share their entrepreneurial experience with one another but also get expert assistance from a variety of service providers in one place (Fig. 2).

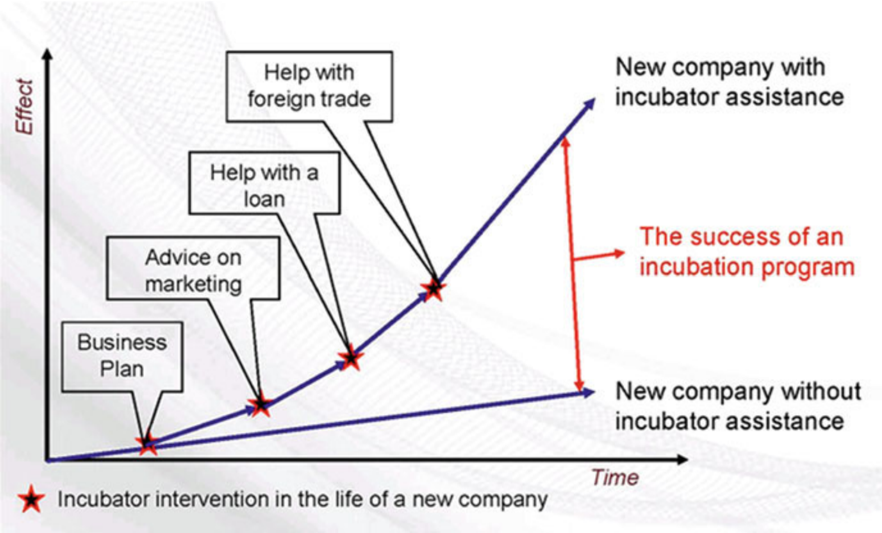

Fig. 3 The figure presents incubator intervention in the life of a new company. This describes how a good incubation programme or centre could help start-ups, e.g. starting from business plans, market understanding and funding. The same is discussed in detail later (Source: Knopp and National Business Incubation Association (NBIA) 2007)

Impact of Incubators

Studying the impact of incubators will allow us to understand what incubation programmes have been able to achieve independent of the sector:

(a) Impact on company performance
Successful completion of an incubation programme has been found to increase the likelihood that a start-up company will stay in business for the long term: Older studies found 87% of incubator graduates stayed in business in contrast to 44% of all firms (Molnar et al. 1997; U.S. Small Business Administration, www.sba.gov/advo). Some authors have argued that incubated firms have low failure rates compared to firms outside an incubator environment (Rothaermel and Thursby 2005) (Fig. 3).

(b) Impact on environment and economy
Incubators also have an impact on the surrounding environment in which they are located. They infuse an entrepreneurial climate in the area, create local jobs, diversify local economies and build and accelerate local industry growth. In 2005, North American incubators alone helped more than 27,000 start-up companies and provided full-time employment for more than 100,000 workers generating annual revenues of more than $17 billion. Data from the National Business Incubator Association also suggests that an incubator programme

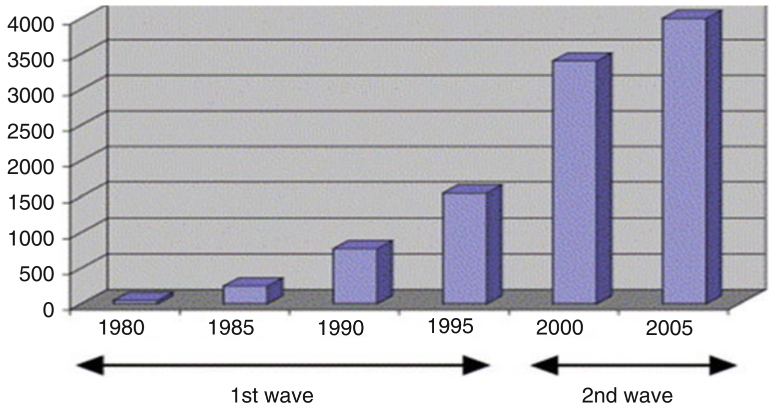

Fig. 4 Increase in number of incubators in the world from 1980 to 2005. The figure shows how from 1980 to 2005, there has been an increase in numbers of incubators. Below we discuss simultaneous growth of start-ups and innovation together (Source: Barrow 2001)

positively effects the growth of a tenant company within an incubator and return on investment for every $1 public investment in the incubator generates $30 in local tax revenue (Knopp and National Business Incubation Association (NBIA) 2007).

Growth of Incubators

The impact of incubators in fostering innovation has been significant and thus has given rise to an increase in the number of business incubators worldwide from less than 50 in 1980 to over 4,000 in 2005 (Barrow 2001) (Fig. 4).

In 2006, the number of incubators in the USA alone was 1,100, almost double the number present in 1998 (Knopp and National Business Incubation Association (NBIA) 2007). Europe has about 1,000 incubators including 300 incubators in Germany. Among the developing countries, China leads with about 100 incubators. Among the industrializing countries, Republic of Korea is reported to have about 300 incubators (Santosh Kumar and Vinay 2010–2011).

Bioincubation: Different from Other Incubation

Let us turn the focus towards incubation process and incubators in life sciences/ biological sciences. Bioscience technology nurturing requirements although similar to other technologies needs specialized support to transform bioscience discoveries into products or technologies on the market. Typically, the transformation process involves longer timelines for development and then commercialization, huge initial and continuous capital investments in infrastructure and expertise across various scientific disciplines and backing from industry, preferably large pharma or VCs – once product is proven.

Bioincubators provide tailored services to life science with particular emphasis on knowledge-driven inventions that involve the development of novel technologies and technology-based firms (Dutton 2009). Apart from the focus of bioincubators on helping develop technology and knowledge-intensive firms, they also provide more specific support services towards IP protection, technology transfer and regulatory affairs assistance. Having world-class researchers nearby also fosters an intellectual climate in which ideas are exchanged easily and partnerships are developed. Consequently, both business and academia are strengthened. Being located in a cluster also provides access to top minds across multidisciplinary fields who may provide their expertise to aid in the development of a discovery into an innovation (Dutton 2009).

Many bioincubators are usually strategically located within research clusters. For instance, many reputed institutions such as Boston University (Boston University Incubator) in the USA, Imperial College in London (Imperial Innovations) and Cambridge University (Springboard) in the UK have incubation programmes to nurture entrepreneurial activity and development of new start-up companies. The accessibility of the budding start-ups to expertise in life science research and interactions with this academic sphere adds significant value to the incubation process.

Need for Incubation in India

In most countries, incubation activity is supported significantly by institutional mechanisms such as providing incubation space in a subsidized fashion to inventors to pursue the path to innovation. In India, there are initiatives and programmes of the Department of Science and Technology (DST) such as Science and Technology Entrepreneurship Parks (STEPs) (http://www.nstedb.com/fsr-tbi09/Images/chapter1.pdf) with an objective of opening doors of self-employment for young science and technology graduates. With the maturity of STEPs in changing economic scenario, the DST established Technology Business Incubators (TBIs) in the year 2000. As of today, there are around 100 TBIs introduced by several ministries including DST (Santosh Kumar and Vinay 2010–2011).

Some of the well-known incubators in India include Society for Innovation and Entrepreneurship (SINE) at IIT Mumbai, Technopark Technology Business Incubator (T-TBI) in Trivandrum and Centre for Innovation, Incubation and Entrepreneurship (CIIE) at IIM Ahmedabad.

SINE at IIT Mumbai has produced companies such as ThinkLABS Techno-solutions, an educational robotics venture, and Myzus Technologies and Elnfinitus. These start-ups have been successful in raising venture capital investment after incubation of up to Rs. 3 crore from the market. In Trivandrum, T-TBI has till date successfully incubated about 60 companies and has had a 92% success rate. In early 2011, T-TBI was chosen as the world's best software-incubating company and the first Indian organization to have achieved this status (http://trak.in/tags/business/2012/03/27/top-5-famous-startup-incubation-centers-india/). CIIE at IIM Ahmedabad has incubated more than 50 companies in the areas of Internet and mobile technology, clean technology, social sector start-ups and healthcare since it started in 2007 (http://trak.in/tags/business/2012/03/27/top-5-famous-startup-incubation-centers-india/).

Whilst this suggests some good incubation programmes/centres, there has been a real need for high-quality incubation programmes/centres in life sciences. Some incubators like IKP Knowledge Park, Hyderabad; NCL Ventures, Pune; Society for Innovation and Development, IISc, Bangalore; and a few others have given a much needed initial push, but the bioscience community needs many more like these. The Dept. of Biotechnology (DBT), Govt. of India, upon realizing this need, has recently announced a large scheme to establish and support high-quality bioscience incubators in the country (http://dbtindia.nic.in/uniquepage.asp?id_pk=18). With such and many more upcoming incubation centres, which have both technical and business capabilities, there is a hope that young ideas and discoveries will be nurtured towards their goal of reaching market as a product or application.

Conclusions

It is known that industry needs academic strength in discovery science as a base to make a substantial social and economic impact. At the same time, academic discoveries require further nurturing to be translated into innovation. This is particularly missing in the life science sectors of developing nations such as India, for instance, where a large number of intellectual contributions from scientists have not been translated into products/technologies on the market. By setting up bioinnovation "hubs" with incubators that are closely associated with research clusters, the process of discovery to innovation can be accelerated. The scenario in India as highlighted above shows that the future is bright for innovative technology development in India; however, it is important that India among other developing nations learns best practices of incubation from the Western countries such as the USA and Europe where there have been innumerable success stories (http://www.nbia.org/success_stories/success/).

Through mentoring incubatees in an incubator environment by providing both scientific and entrepreneurship/business expertise, providing state-of-the-art working laboratories, cutting-edge technology platforms and strategically "nucleating" incubators in existing bioclusters, an ecosystem that nurtures and supports discoveries can be created and can put budding entrepreneurs with exciting discoveries on the path towards commercialization or productization.

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An Integrated Talent Management System for Maintaining an Up-to-Date Technical Workforce

Harold G. Kaufman

Introduction

For an organization to successfully compete in today's global marketplace, the intellectual capital represented by the knowledge and skills of its technical workforce must remain up to date. It is ironic that the workers most responsible for technological change (engineers, IT specialists, and other technical professionals) have long been recognized as among the most vulnerable to its consequences – the rapid obsolescence of their knowledge and skills (Kaufman 1974a, 1975).

While obsolescence pertaining to people had been recognized as an organizational problem as far back as 1930 (Kaufman 1974a, 2006), concern over the issue became widespread following the rapid changes in technology that began during the post-World War II era. These changes included the rapid development of solid-state and computer technologies that accelerated the obsolescence of technical professionals. The so-called "half-life" of technical knowledge acquired through education rapidly diminished during this period (Kaufman 1974a, 2006; Zelikoff 1969). In addition, the advent of the Cold War and the long competition between the USA and the Soviet Union, especially the space race, spurred the rapid creation of new technical knowledge.

In the United States, the problem of obsolescence among technical professionals was addressed at many conferences as well as by a deluge of articles and research starting in the 1960s that continued unabated in subsequent decades (Kaufman 1974a, 2006). For many years this concern was concentrated largely in the United States and focused on engineers. But as technology spread globally, articles and research about obsolescence began to be generated in many countries throughout the world.

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In addition, the focus began to shift gradually from engineers to IT professionals as computer technologies became widespread. Today, obsolescence is even more of a threat to individual careers as well as to the survival of organizations on a global scale. This concern was expressed in an article from India about obsolescence with the subtitle: “A Wake-up Call to Avert a Crisis” (Chauhan and Chauhan 2008: 85).

Defining Obsolescence

Obsolescence has been defined as “the degree to which organizational professionals lack the up-to-date knowledge or skills necessary to maintain effective performance in either their current or future work roles” (Kaufman 1974a: 23). This definition of obsolescence includes several essential concepts, as follows:

A Lack of New Knowledge or Skills

Obsolescence occurs when the technical professional fails to keep up to date with new knowledge or skills. However, this is a matter of degree. Technical professionals need to stay current, although few are totally obsolete, and not many are completely up to date.

Ineffectiveness

Obsolescence becomes a problem when it leads to ineffectiveness. However, only ineffectiveness that results directly from a *lack* of current knowledge and skills should be attributed to obsolescence.

Job and Professional Roles

Technical professionals who lack the knowledge or skills necessary to perform effectively in their current work roles experience job obsolescence. When technical professionals do not keep up to date more broadly with new developments in their field or discipline, they become professionally obsolescent. Such obsolescence can impair their effectiveness in taking on new work roles.

Causes of Obsolescence: An Open Systems Model

There are multiple and complex contributing factors to the onset of obsolescence among technical professionals. An open systems model approach (Katz and Kahn 1978) has been applied to obsolescence that shows some of the interactions of the internal system components with the external environment (Kaufman 1978, 1979, 1989).

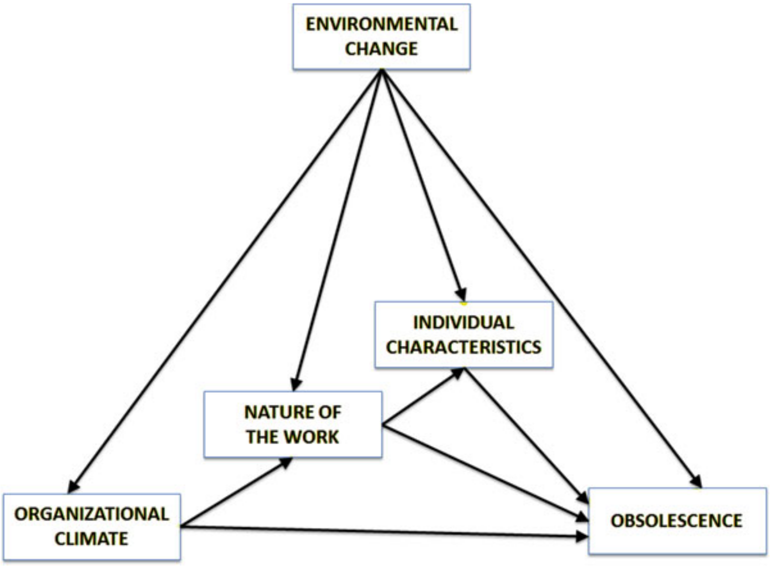

Fig. 1 A systems model of obsolescence

According to the model, four broad system components have been identified that are likely related to obsolescence as well as to each other (Fig. 1). These components and their interrelationships can be summarized as follows:

1. *Environmental change* is at the root of obsolescence and is all-pervasive, involving the rapidly changing technology, the information explosion, and the exponential rate of increase in technical knowledge. Other external forces such as organizational restructuring, global competition, and workforce changes tend to exacerbate the problem. Such environmental change has been the driving force toward creating a knowledge economy that produces and distributes ideas and information (Drucker 1969). Environmental change is depicted in the systems model as not only affecting the obsolescence of technical professionals directly but also individual, work, and organizational factors (Fig. 1).
2. *Individual characteristics* of technical professionals can affect their degree of obsolescence. These include individual differences that may either predispose technical professionals to keep abreast of new developments or contribute to their becoming out of date. These individual differences have been identified as demographic (e.g., age) or psychological in nature, involving cognitive, motivational, and personality characteristics (Kaufman 1974a).
3. *Nature of the work* carried out by technical professionals is a critical factor contributing to obsolescence, both directly and by its effects on individual characteristics (Fig. 1). Nature of the work involves job assignments and the degree of challenge and growth provided, including knowledge and skill utilization. Poor utilization negatively affects the growth and development of technical professionals, and it is most detrimental if it starts early in the career (Kaufman 1974a).

4. *Organizational climate* involves aspects of the work environment that are a consequence of management policies and practices, such as those related to professional career development or the organizational reward system vis-a-vis keeping up to date (Kaufman 1974a). According to the model, organizational climate not only has a direct effect on obsolescence but also impacts the nature of the work (Fig. 1).

The open systems model depicted in Fig. 1 addresses the complexity of obsolescence in a parsimonious fashion in order to identify its multifaceted causes and their interrelationships. There is evidence that the systems model presented here has validity (Kaufman 1978, 1979, 1989; Nwachukwu 1989; Trimmer et al. 1998). Nevertheless, such evidence should not preclude the validation of other models of obsolescence and updating that have been proposed (Dubin and Cohen 1970; Farr and Middlebrooks 1990; Fossum et al. 1996; Joseph et al. 2010; Kozlowski and Farr 1988; Rong and Grover 2009).

An Integrated Talent Management System

The four components of the open systems model that can lead to obsolescence may be addressed by organizations through the use of an integrated talent management system. Such a system would utilize appropriate interventions and practices intended to develop and maintain an up-to-date technical workforce as part of the overall organizational strategy. Talent management has become widely accepted in US industry and has a variety of definitions (Silzer and Dowell 2010). In a major research study by the Society for Human Resource Management, talent management was defined "as the implementation of integrated strategies or systems designed to improve processes for recruiting, developing and retaining people with the required skills and aptitude to meet current and future organizational needs" (Fegley 2006: v). Developing and implementing an integrated talent management system can be extremely useful to not only address the internal components of the model that can cause obsolescence – the individual characteristics, nature of the work, and organizational climate – but also the external environmental changes. Such a proposed integrated talent management system is presented in Fig. 2.

Environmental-Organizational Interface: Monitoring Obsolescence

Environmental Scanning

Environmental change is all encompassing and impacts the other factors affecting obsolescence. Organizations can monitor such change through environmental scanning, which involves the acquisition and use of information related to technology,

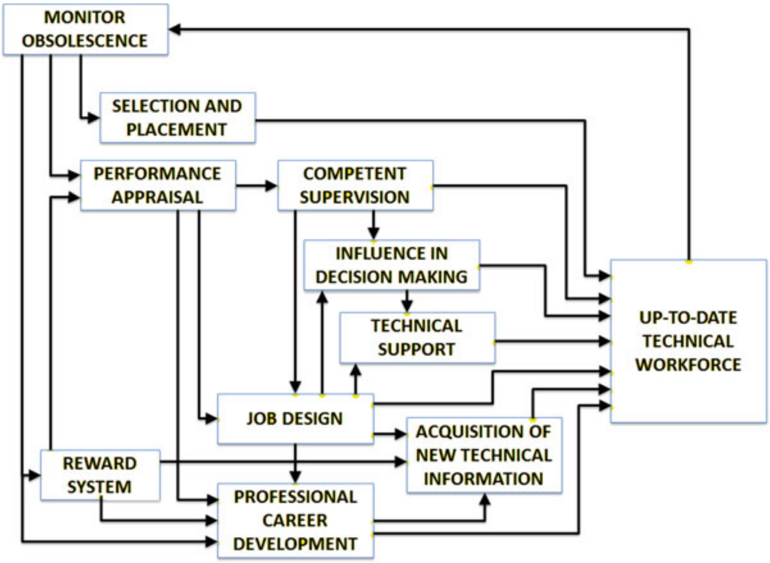

Fig. 2 An integrated talent management system for maintaining an up-to-date technical workforce

competitors, customers, suppliers, and other market-related aspects of the organization's external environment (Choo 2001). Environmental scanning is the principal method of strategic organizational learning involving the import of explicit knowledge, which is knowledge readily accessible for easy communication and utilized by the organization to develop new products, processes, and innovations (Nonaka and Takeuchi 1995). When environmental scanning is combined with forecasting technological and other changes likely to affect obsolescence, the organization can use the information in its strategic planning to identify competency gaps for maintaining an up-to-date technical workforce. However, only about half of the organizations with talent management initiatives attempt to identify gaps in competency levels for current or prospective employees (Fegley 2006). Moreover, identifying competency gaps is also one of the practices most in need of improvement. Monitoring the environment is critical as the first step in achieving a technically competent workforce utilizing the integrated talent management system illustrated in Fig. 2.

Knowledge Loss to the Environment

Technical knowledge gaps in organizations can not only occur because of external environmental change but also as a result of knowledge loss from inside the organization to outside its boundaries, which also requires monitoring. Organizations experience a loss of knowledge when technical professionals leave the organization as a result of retirement as well as voluntary and involuntary termination. When such individuals leave, the organization loses its tacit knowledge, which constitutes the largest part of what one knows and is acquired largely through experience and interactions with others (Polanyi 1966, 1976). The retention of tacit knowledge and its importance to organizations has become the focus of recent research (Levy 2011; McQuade et al. 2007; Martins and Meyer 2012). Monitoring tacit knowledge possessed by technical professionals leaving their firm in order to transfer it to those remaining helps preserve the intellectual capital of the organization.

Metrics for Monitoring

Various metrics for monitoring obsolescence in the organization have been identified, including the use of relevant personnel record data such as education and training activities, professional contributions, and skills inventories (Kaufman 1974a, 1990). While tests of knowledge may be the most direct way of monitoring obsolescence (Mali 1975), they are difficult to implement. On the organizational level, periodic attitude surveys may provide a much easier way to monitor obsolescence. For individuals, self-assessment instruments have been used to evaluate the degree of obsolescence among technical professionals in organizations (Kaufman 1978, 1979, 1989). Whatever approach is used, the goal should be to monitor obsolescence with a valid metric.

Individual Characteristics

There are standard talent management techniques that organizations can use that focus on individual characteristics for the purpose of maintaining an up-to-date technical workforce. These include selection and placement as well as performance appraisal. Results of various monitoring processes should have a direct input to these techniques (Fig. 2).

Selection and Placement

Recruiting and onboarding are fundamental functions in talent management (Silzer and Dowell 2010). As part of these functions, organizations can address individual differences among job applicants by applying effective techniques of selection and placement to maintain an up-to-date technical workforce (Kaufman 1974a, 1990). The goal is to achieve a good fit between the knowledge and skills, as well as motivation, of technical professionals and their current and future job requirements, based on the results of environmental monitoring. Organizational fit must also be considered in selection and placement, since a mismatch can detrimentally affect the maintenance of technical competency (Wingreen and Blanton 2007).

Given that the first job experience can be crucial to the career development of technical professionals (Kaufman 1974a, b), obsolescence can be controlled from the very start by achieving a good fit between new hires with their job requirements and organization.

Performance Appraisal

Various techniques of periodic performance appraisal are integral to practically all talent management systems (Fegley 2006). It should be noted that such evaluations are an important component of current performance management systems that also include feedback and coaching (Aguinis 2009). The latter are typically part of talent management systems, including the one being proposed. Performance appraisals should not only focus on current gaps in knowledge but also on future potential and career development needs to prevent obsolescence, again based on the results of environmental monitoring. Appraisal techniques utilizing goal setting and feedback, such as management by objectives (MBO), have long been advocated as an approach to prevent technical obsolescence (Horgan and Floyd 1971). Moreover, appraisals of future potential also can be made by utilizing assessment center techniques for the purpose of professional career development (Kaufman 1974a).

Nature of the Work

A central system component directly related to obsolescence is the nature of the work (Fig. 1). The evidence indicates that work assignments are the major factor contributing to the onset of obsolescence among technical professionals (Kaufman 1974a, b, 1978, 1979, 1989; Kozlowski and Farr 1988; Newton et al. 2002). Moreover, individual characteristics can be affected by the nature of the work (Brousseau and Prince 1981). The results of performance appraisals can be applied directly to improving job design as well as enhancing the competence of supervisors, which can affect their decision making and how they design jobs (Fig. 2).

Job Design

While job design is sometimes included in talent management systems (Silzer and Dowell 2010), it can play an important role in maintaining an up-to-date technical workforce. One of the most important needs of technical professionals is challenging work that utilizes their knowledge and skills, but many are not well utilized (Kaufman 1986, 2006). Poor utilization detrimentally affects professional career development, which can start early in the career. Redesigning the work of technical professionals entails, in part, using job assignments to motivate learning new knowledge and skills (Kaufman 1974a, b, 1978, 1979, 1986). Obsolescence is likely to occur among technical professionals when their work becomes so specialized that the broader base of knowledge and skills is not used and forgotten. Therefore, job design should emphasize a diversity of challenging work assignments that require on-the-job problem solving that involves learning new knowledge and skills. Such an approach results in what has been referred to as *smart jobs,* “that can stimulate learning, growth, and employability” (Hall and Las Heras 2010: 448). Since technical professionals typically are assigned to projects involving teamwork, job design must also take into account the social as well as individual factors affecting group performance (Oldman and Hackman 2010).

Competent Supervision

The identification and development of high-potential employees is usually a component of talent management (Silzer and Dowell 2010). The performance appraisal process can use various techniques, including peer assessments, to select supervisors of technical professionals based on competence in their field or specialty. The support of the immediate supervisor plays a significant role in the updating of technical professionals throughout their career (Pazy 1996). Moreover, the supervisor is critical in determining job assignments as well as providing oversight, thereby shaping the knowledge and skill utilization of those in their work group (Kaufman 1974a, 1995). Utilization of knowledge and skills can be a problem for technical professionals whose supervisors are themselves obsolescent and cannot properly evaluate technical performance (Farr et al. 1983). It is the technical competence of supervisors that provides the basis of their influence as leaders of their work group (Kaufman 1974a). Therefore, the development of technical professionals through techniques such as participative goal setting, performance feedback, or career coaching can depend on how well their supervisor possesses the up-to-date knowledge and skills relevant to their work.

Technical Support

Job design should address the need for technical support to achieve the proper utilization of technical professionals. This support includes technical and clerical assistance as well as up-to-date computer hardware and software plus any equipment required to achieve high levels of performance (Kaufman 1986). While the technology provided may be adequate, the support personnel often are not. It is the lack of technical and clerical assistance that has been a major factor in the proper utilization of technical professionals, which ultimately affects their obsolescence. Therefore, the job design process should lead directly to the provision of effective technical support (Fig. 2).

Organizational Climate

The final component of the systems model of obsolescence to be addressed is organizational climate (Fig. 1). Definitions of organizational climate typically emphasize an organization's observable practices and procedures as perceived by its members (Denison 1996). There is consistent evidence that organizational climate can have a major impact on obsolescence as well as determining the nature of the work (Kaufman 1978, 1979; Joseph and Kuan Koh 2011; Nwachukwu 1989; Steiner and Farr 1986; Trimmer et al. 1998). Moreover, the most important climate factor differentiating organizations was one that supports updating and professional development (Kozlowski and Hults 1987). While there are many organizational practices and procedures that may contribute to reducing obsolescence (Kaufman 1974a, 1990), a select few will suffice that are appropriate for the integrated talent management system proposed (Fig. 2).

Influence in Decision Making

Organizations utilizing talent management practices are significantly more likely to empower employees to make decisions that impact their work (Fegley 2006). Increasing the influence of technical professionals in the decision-making process may be accomplished through effective supervision and job design to enhance responsibility and control over their work, as depicted in the integrated talent management model (Fig. 2). Technical professionals desire to have such influence over decisions pertaining to their work, but those needs may not be met (Kaufman 1986). Providing greater responsibility and control to technical professionals serves to create a climate that encourages autonomy in the pursuit and development of new ideas, which results in a more up-to-date workforce. This can be accomplished through the restructuring of groups and individual roles. For example, autonomous team structures are delegated a high degree of responsibility and control which can result in rapid and efficient new product or process development (Clark and Wheelwright 1992). Such team structures have been referred to as “hot groups” and what helps keep them hot is their autonomy and independence from organizational bureaucracy (Leavitt and Lipman-Blumen 1995). A different approach that focuses on individual autonomy is that of intrapreneurship, which encourages individual initiative to pursue and champion new ideas (Pinchot 1987). Regardless of which techniques are used to increase technical professionals’ influence in the decision-making process, such practices should serve to directly stimulate the development of a technical workforce that is up to date (Fig. 2).

Reward System

Most talent management programs include reward systems other than compensation (Fegley 2006; Silzer and Dowell 2010). As shown in Fig. 2, the results of monitoring obsolescence serve as direct inputs to the reward system. Environmental scanning of technological, human resource, and other changes likely to affect obsolescence provides information that can be used by the organization to better design reward systems for maintaining an up-to-date technical workforce. In fact, the reward system is most valued when it provides challenging work assignments (Steiner and Farr 1986). Although financial rewards are important to technical professionals, the nonmonetary or intangible rewards are often more critical in motivating and reinforcing updating and career development activities (Kaufman 1974a). For example, the best reward for successful intrapreneurs is more freedom, together with a budget, to pursue the development of new products or processes (Pinchot 1987). Nevertheless, it is questionable whether many technical professionals feel they are rewarded adequately (Kaufman 1986). Here is where the performance appraisal system needs to be designed to function more effectively together with the reward system in motivating professional career development as well as the acquisition of new technical information (Fig. 2).

Professional Career Development

Career planning and development activities are usually included among talent management practices (Silzer and Dowell 2010). Organizations utilizing talent management initiatives were found to be significantly more likely to have policies that encourage career growth and developmental activities (Fegley 2006). However, such policies were among those most in need of improvement in organizations that had a talent management system in place. Such improvement can be accomplished by first addressing the monitoring, performance appraisal, reward system, and job design components of the integrated talent management system, all of which can affect professional career development (Fig. 2).

Firms in the USA have long focused on continuing education as the way to deal with the obsolescence problem (Dubin 1990; Kaufman 1974a, 1975, 1982a; National Research Council 1985; Rosen and Jerdee 1985). This may be attributed to the half-life of a technology-based education, which has been rapidly diminishing as a result of changing requirements for technical knowledge and skills. Fields impacted by changes in information technology typically have the shortest half-life and have the greatest need for updating.

Most formal continuing education for technical professionals in US industry has been in-house and noncredit (National Research Council 1985). Such courses can be offered via e-learning, which appears attractive to technical professionals who are early adopters of this mode (Gallaher and Wentling 2004; Waight and Stewart 2009). Despite the fact that continuing education is considered important by technical professionals for their career development, they do not feel that their employers encourage them to participate (Kaufman 1982a, b; National Research Council 1985; Engineering Manpower Commission 1986). One approach to address this dilemma is to use the work itself to motivate formal as well as informal professional development. Here is where the talent management components can be applied to stimulate career growth through job design, performance appraisal, and reward system. There is evidence that an organizational climate that encourages updating and fosters professional growth also provides challenging work assignments (Kozlowski and Farr 1988). Such a professional, growth-oriented climate can be created by supervisors assigning challenging jobs that require technical professionals to learn new knowledge and skills through continuing education or other career development activities. In organizations where the technology has totally changed, retraining and redeployment are viable options as an alternative to termination (Kaufman 1982b, 1995, 1994).

Acquisition of New Technical Information

Professional career development activities, together with the reward system and the design of the job, can have a direct influence on the acquisition of new technical information (Fig. 2). This is a unique component of the integrated talent management system for maintaining an up-to-date technical workforce. Without adequate access to new technical information, obsolescence of knowledge and skills is inevitable. Interactions with colleagues are a major source of information required by technical professionals (Allen 1977; Kaufman 1974a, 1984). Therefore, open communication, internal as well as external to the organization, is necessary for staying up to date. However, technical professionals have been frustrated in gaining access to new technical information (Kaufman 1986; Engineering Manpower Commission 1986). The nature of interorganizational competition puts constraints on the open sharing of information among technical professionals outside their own firm (Allen 1997). There can also be a reluctance to share information internally (Klein 1998). Nevertheless, more open communication, both internally and externally, is necessary to acquire new technical information to assure an up-to-date climate. There are a number of practices that can improve the information acquisition process. The role of technological gatekeepers is critical in acquiring information externally and disseminating it internally (Allen 1977). The effectiveness of such gatekeepers can be enhanced through information dissemination systems. Even the reluctance to share information internally can be addressed. For example, organizations see wikis as an up-and-coming technology for supporting collaborative work (Arazy et al. 2009). However, the introduction of any electronic system for information sharing may require a culture change involving the reward system (Klein 1998). The information acquisition process is linked via the reward system to the monitoring of obsolescence, which is the initial component in the proposed integrated talent management system (Fig. 2). In essence, this integrated system begins and ends with related processes of environmental scanning for new knowledge and information acquisition to maintain an up-to-date technical workforce, with a feedback loop to monitoring obsolescence.

Conclusion

The widespread problem of knowledge and skill obsolescence among technical professionals has traditionally been addressed on a piecemeal basis. What is being proposed here is an integrated talent management system that would utilize appropriate interventions and practices to develop and maintain an up-to-date technical workforce. In order for such a system to be effective, it must be an integral part of the overall organizational strategy and have commitment from top management.

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Designing and Operating Communities of Practice for Managing Knowledge: Lessons from a Comprehensive Global Knowledge Management Survey

A.D. Amar and Elayne Coakes

Introduction

The most difficult task of managing knowledge in organizations is the management of tacit knowledge—the uncodified knowledge that resides in the minds of employees and is very difficult, or too dynamic, to be codified to be usable. Employees acquire it through experimentation, experience, and erudition. And the latter is the only means by which it is disseminated. Organizations have always found it difficult to manage, but even more difficult has been its transference from one knowledge worker to another. Nevertheless, history tells us that humans, through social processes, have successfully engaged in transference of tacit knowledge for as long as they have operated in groups. Going back, examples of such groups or communities, in concept, without bearing the name communities of practice, appear in records of classical Greece and the Middle Ages (Wenger 2006). Such groups dominated the societies of their times and controlled power. Most recently, during the 1970s, the Japanese attempted the management and transference of tacit knowledge by employing *quality circles.*

In essence, a community of practice (more commonly referred to as CoP) came to the business world mainly during the last decade. Just like the communities of the ancient times described above, and the quality circles of the 1970s, communities of practice (CoPs) become a forum for interaction to create and disseminate knowledge among members of a community pulled together by their interest in knowledge

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common among them. As we will describe in later sections of this chapter, organizations use CoPs for different goals and name them differently. One type of CoP described by Wenger et al. (2002) for bringing together people with common problems, concern, and/or passion is named *organizational communities of practice.* While in operation, any CoP may appear to be like another version of a *quality circle;* in its formation and function, it is quite different and the CoP system is relatively new. The major defining point of a CoP, according to Wenger and Snyder (2000), is that it operates within the realm of an organization. The basic aim of operating a CoP is to be able to get enhanced performance and innovation from knowledge workers (Brown and Duguid 1991). Because of the importance of innovation from communities of practice, Coakes et al. (2011) emphasize a special form of CoP named the community of innovation (CoInv).

Defining CoP

The most commonly accepted definition of a CoP is that of Wenger's (2006) whereby a community of practice is a group formed by those who engage in collective learning in a domain of human endeavor that is shared by all in the group. It is a group of people with common interests coming together to learn more about their interests by engaging in regular interaction to share their ideas. Although Wenger (2006) does not specify, however, it is implied that CoPs, in addition to learning, also involve teaching.

Wenger (2006) gives three characteristics identifying a community of practice: (1) A CoP is not a collection of random people. These people share a *domain* of similar interests and a desire to learn and develop their knowledge base of these interests. (2) The second characteristic of a CoP is *community,* which means that members of a CoP identify themselves with their community of practice and want to develop relationships with other members of their CoPs. (3) The third characteristic of a CoP is *practice,* conveying emphasis on practice of the knowledge they learn and impart in the CoP. They are considered practitioners of the knowledge of their CoP. They share practice in approaching and solving problems that come up at their community of practice.

All members of a CoP have to take an important role in the functioning of their CoP. Members not taking an active role in their CoP could make the CoP irrelevant which will eventually cease to exist. According to Wenger and Snyder (2000), CoPs are informal in operation. Communities of practice organize themselves, set their agenda themselves, and decide their leader(s) themselves. Membership of a CoP is voluntary. Only those who find the utility of a CoP to them should join. CoPs should not be formed by the management. Management should neither encourage nor discourage CoPs. CoPs should come up naturally at the initiative of those who see benefit coming to them from forming, operating, and belonging to it. The members should set the CoP parameters to assure that only what interests them remains

What technology or other tools are used to manage explicit knowledge in your organization?

- Intranet
  - Source of information
  - Every one in touch
  - Learn about the company (business, policies, strategy, goals)
  - Learn about competitors
  - HR (feedback, employee benefits, training, development)
  - Internal knowledge repository with update info and standards
- Blogs
  - Employees discussions
- Chat
  - Flexibility
  - Share ideas virtually
- Online courses / live seminars / webinars / videos
  - Development of professional skills
- Human instinct – human interaction, such as communities of practice

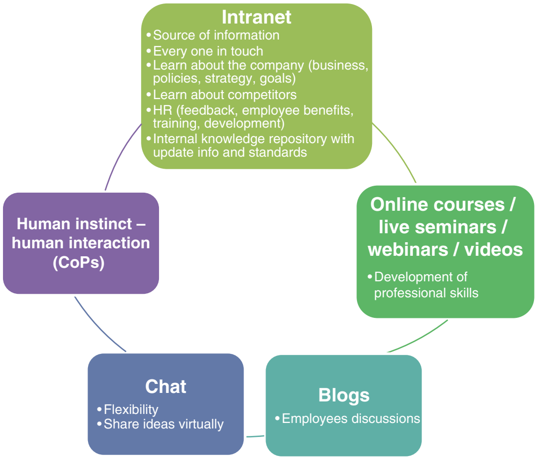

Fig. 1 Tools used to manage knowledge in organizations

relevant in the CoP; however, group members must come together and relate to each other through personal interaction.

In contrast to many tools used in managing knowledge, such as intranet, blogs, chat, webinars, human instinct is a required element of communities of practice. Figure 1 provides all these tools.

Forming and Operating Communities of Practice

There is a growing interest in organizations globally in understanding how to employ communities of practice to enhance learning and organizational performance (Kirkman et al. 2011). However, with the introduction of communities of practice being new in organizations, an obvious question managers ask is how to design and run these CoPs to make them useful to their organization. Finding an answer to this question is the main objective of this research: We want to find some guidelines about forming and operating successful communities of practice. Since practice is one of the main themes of CoPs, we decided to engage in survey research covering knowledge workers, managers, and senior executives in many industries. Furthermore, recognizing the expanding role of knowledge in all operations in almost all organizations (small and large) in all countries (developed and developing) around the world, we also decided to make this survey global, representing as many countries as possible.

When designing this survey-based research, we found that it was vital to be aware of the following five things: (a) the hypotheses addressed; (b) the questions coming out of the hypotheses; (c) the unit of analysis of responses; (d) the logic that would link the data to the hypotheses; and (e) the criteria for interpreting the findings. Each hypothesis must direct attention to at least something—in the form of questions—to be examined within the scope of study. Each piece of data collected should also match to the hypotheses, taking into consideration that a real-world situation, which is what was being considered in this study, is inevitably complex and multidimensional, and thus, any hypotheses, it can be argued, can be matched to more than one type of data.

Recognizing the gaps in understanding, discussed in the above section, the authors undertook a very large, comprehensive knowledge management study through cooperation between two universities, one in the USA and the other in the UK, which had respondents from 76 countries, all continents and many small island states, such as East Timor, Trinidad and Tobago, and American Samoa. A section of this global study was intended to learn about designing and operating CoPs for knowledge management. It lasted more than four years, from July 17, 2007, to November 14, 2011. It has had over 1,034 participants with a 69.5% completion rate (note that many questions are optional so this will be indicated by the final completion rate).

The Survey Design

The authors developed a comprehensive set of ten hypotheses for this survey to consider the formation and management of communities of practice. Table 1 lists these hypotheses in the first column, which were tested through a number of Likert-ranked statements in the survey. The second column of this table includes the questions that were devised to test the corresponding hypotheses of the first column. Table 2 provides a list of the major questions of this comprehensive survey that pertain to the study of communities of practice.

To assure that the participants were not just answering questions without reading and considering, some random negative statements were added. Additional questions were added to other sections to investigate other phenomena related to knowledge management (KM) such as the ideal knowledge leader based on the work by Cavaleri and Seifert (2005), questions relating to how communities of practice were operating, and some additional open questions.

This survey was undertaken through the communicative approach to research which investigates questions that relate to attitudes, motivations, intentions, and expectations and thus could be undertaken through a web-based survey. To overcome a weakness of this approach, i.e., the willingness of people to participate and then to tell the truth, the survey allowed respondents anonymity unless they

Table 1 Hypotheses and ensuing questions used to learn formation and operation of communities of practice

The organizational type and sector will have an influence on how knowledge management is shared within itself (Q3, Q4)	
1. Will influence whether or not there is knowledge sharing with external entities such as partners that occurs	Q33 We are proactive in analyzing and reporting on what is happening outside our organization and how we might be affected by these external developments
	Q34 We enhance our own organization's knowledge through involvement in collaborative working with other organizations
	Q54 Our CoPs partner CoPs in our allied/partner companies
	Q55 We share the development of new products or processes with CoPs in our partner organizations
2. (a) Whether or not CoPs occur at all	Q38 We normally work together in CoPs
(b) Whether or not CoPs are formally or informally set up (the level of formality for CoPs)	Q39 CoPs are used to support the development of new working practices
(c) The level of resources for CoPs	Q40 Working in a CoP is expected practice in my organization
	Q47 The organization has allowed us to set up our own CoPs
	Q48 We would like to be able to set up our own CoPs but are not permitted to do so
	Q49 CoPs are formal structures in our organization set up by management
	Q50 We are supported with resources for our CoPs
	Q59 CoPs are used to develop new organizational knowledge
3. (a) Whether rewards are offered for knowledge sharing	Q31 We have a range of different rewards in this organization to motivate us to contribute our personal knowledge to the collective repository
(b) Whether targets may be set in return for resources	Q40 Working in a CoP is expected practice in my organization
(c) Whether or not they assist in developing strategy (Organizational type/sector affects expectations of CoP outcomes)	Q44 We do not expect targets to be set for our CoPs
	Q56 We can bid for resources for our CoPs but have to achieve targets in return
	Q57 Our management expects our CoPs to produce outcomes
	Q58 Our management has no expectation from our CoPs other than the sharing of knowledge

(continued)

Table 1 (continued)

	Q93 Internal competition for promotion has decreased due to knowledge sharing
	Q95 In my organization, there is a policy in place that links the ability and willingness to share knowledge with rewards
4. Whether creativity is enhanced or decreased with ease of knowledge access, e.g., through CoPs	Q91 The ability to easily access other people's knowledge has made me less creative
	Q92 As I cannot easily locate the knowledge I require, I have become more creative
5. Whether there is more or less technology to support knowledge sharing and CoPs. Less technology = more sharing; more technology = less sharing	Q14 There is a formal system in my organization for the purpose of capturing the knowledge aspects of our business experiences
	Q15 My organization does not employ any specific technology for the purpose of managing collective knowledge (normalize)
	Q30 Our intranet is the primary channel of internal communication for exchanging ideas, information, and knowledge
6. Organizational makeup: large size = more CoPs	Q5 Approximately how many people are employed at your location?
7. Organizational culture affects knowledge sharing and the creation of CoPs:	Q2 Please state in which country your organization's headquarters are located
(a) The amount of change is sector related—fast versus slow—and thus, there will be a culture more or less able to cope with change. The more change there is, the more likely there are to be CoPs	Q11 My organization has clearly stated values, which guide the way we work here
(b) The country of the organization will affect willingness to create and use CoPs (national cultures)	Q12 There are key beliefs in our organization, which are shared by all of those working here
(c) Will also affect clearly understood values and beliefs	Q28 The culture in my organization supports knowledge management
(d) Will affect the Development of trust	Q45 Change is normal in our organization and our CoPs support new ways of working
	Q46 Managers run our CoPs
	Q96 My organization has a culture of mentoring new staff and sharing knowledge with them
	Q97 The organizational culture is suspicious of knowledge sharing
	Q100 We regularly work within multidisciplinary teams, and thus, knowledge sharing within these teams is normal practice

(continued)

Table 1 (continued)

	Q101 We never or rarely work within multidisciplinary teams, and thus, it is difficult to know people outside my department
	Q102 I do not trust people in my organization until I have met them face to face
	Q105 We do not have a clear knowledge-sharing training policy and events
8. Organizational type/sector affects whether CoPs develop innovation—new products, services, business processes:	Q51 CoPs support the development of innovation in our organization
(a) Fast = more innovation	Q52 New ideas for products come from our CoPs
(b) Slow = less innovation	Q53 Our CoPs develop new working processes
(c) Innovatory knowledge is more or less shared more widely throughout the organization	
9. Organizational type/sector impacts on empowerment and self-realization (a) impacts on whether or not working in CoPs is permissive/normal practice/demanded	Q29 My organization does not encourage self-development
	Q32 A feature of my organization is that we are empowered to achieve our performance objectives
	Q41 We use CoPs to enhance our individual knowledge
	Q43 We choose to work in CoPs as a matter of normal practice
(b) Whether or not CoPs have helped develop knowledge taxonomies and languages	Q18 We use a particular knowledge management language between ourselves that enables us to exploit knowledge in my organization
	Q42 Our CoPs have developed their own working language
If the Participant is younger, with higher education, their gender, and their experience of KM will affect their ideas relating to knowledge sharing and CoPs working	Q61 Gender
	Q62 Age range
	Q63 Final academic qualification
	Q7 If yes, please state how long have you been involved with KM: year

expressed a willingness to participate in a follow-up in-depth study. Views of many of these respondents as well as the follow-up interviews are included in the discussions in this chapter.

Since participants can interpret questions differently from how intended, the authors used questions that tested some areas of response in different ways in an attempt to cross-check and to increase the reliability of this survey. Several questions were also included where answers could be worded by the respondents as they wished—in free-form text—to permit their explanation of the topic under inquiry. This permitted the inclusion of their views.

Table 2 Major questions used to test hypotheses on forming and operating communities of practice

Q13: There is a clear, well-understood knowledge management strategy in my organization that guides us with the knowledge aspects of our business experiences.
Q16: We did not normally work in teams, but the introduction of the knowledge management program has resulted in people working together in teams.
Q17: In my organization, the knowledge management program has resulted in people working together in communities of practice.
Q19: Our knowledge is clearly structured, making it easy to add to and draw from it.
Q20: My organization does not have a policy requiring that its knowledge is centrally managed.
Q21: Responsibility for my organization's collective knowledge is given to one designated person.
Q22: There are clearly defined processes and rules, which specify how knowledge must be managed.
Q23: My organization selectively disseminates knowledge.
Q24: My organization encourages knowledge exploitation.
Q25: As individuals, we share our knowledge through collaboration.
Q27: Our business strategy is developed out of what we learn from sharing knowledge.
Q35: We do not have a formal structure to assist us with knowledge management; we are left on our own to practice and learn.
Q86: Do you feel that you have a good overview of organizational knowledge and where it is located in your organization?
Q87: What is the most common route you take for you to find out where knowledge is located and who owns this knowledge?
Q90: What are the major organizational barriers that you encounter in locating this knowledge? (open question)
Q98: Many people in my organization believe that knowledge equals power.
Q99: I am happy to share my knowledge within my department but not outside of it.
Q104: Our organization has a clear map of where knowledge is located and who holds it.

The Sample

We surveyed 1,034 participants, from July 17, 2007, to November 4, 2011, from 76 countries, and while the responses are predominantly from the USA and the UK (71%)—an expected result due to the nature of the topic being discussed and the likelihood of such activities being performed—the third most responses, however, come from India, closely followed by Australia and China. There is a representation of many countries that are atypical in such surveys or are from small developing countries, such as East Timor, Trinidad and Tobago, and American Samoa. Our sample includes even the Vatican as they use and manage knowledge like many other organizations. Note that this survey is extremely large[1] and covers more countries than any other KM survey. Additionally, this survey covers all sectors and sizes of organizations. This, therefore, qualifies to be the largest global knowledge management survey and the only one to include countries outside the expected norm. A complete breakdown of all participants in this study is represented in Fig. 2.

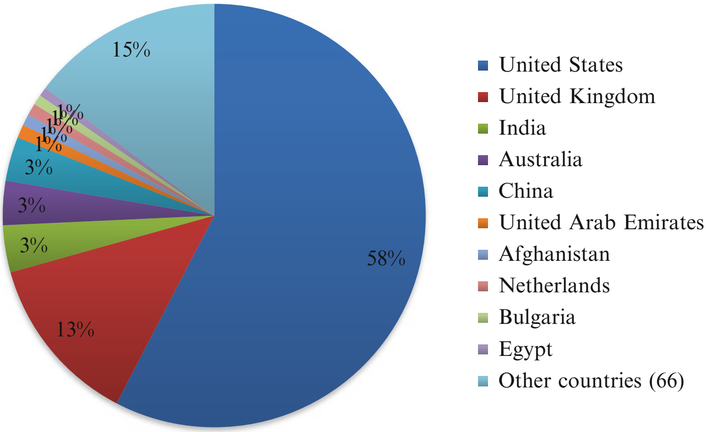

Fig. 2 Country share of respondents in the study

The participants in our survey come from all levels of managing knowledge in organizations of all kinds. They represent all sizes and kinds of businesses including the third sector and SMEs and organizations that one may not have thought of before as being knowledge based. The survey includes not just the senior managers responsible for KM decision-making and those who carry out the KM function but also those who use knowledge—the knowledge workers. Table 1 gives the demographics of our survey sample including those who participated in the follow-up interviews. The respondents included 92 who either owned (9) or were CEO (20) or were a director in their organization. Some 177 were managers of various departments; 140 were technicians or engineers or information and communication technology (ICT) employees; but also one respondent was involved in nuclear power plant design, several were scientists for governmental agencies, and one was a Senior Chyron Operator. Health practitioners of various types, as knowledge workers, were also represented in our sample including a pharmacovigilance specialist and a clinical safety associate; 4 respondents were chaplains or involved in pastoral work; 1 was involved in preserving, perpetuating, and making publicly accessible the legacy of a preeminent American visual artist; 19 or more were involved in consulting; and there were a number of academics who responded to our survey including a dean and director of curriculum and ten faculty members of universities. This breadth of survey participation gave us a unique insight into how knowledge is managed in numerous areas of organizations as well as for numerous purposes (Tables 3 and 4).

Table 3 Demographic information of sample

Industry	Frequency	Percentage (%)
Services (e.g., banking)	313	30
Education	167	16
Health Care	144	14
Manufacturing	142	14
Consultancy	94	9
Retailing	78	8
Government (local)	67	6
Government (not for profit e.g., C)	28	3
Scope		
Multinational	140	14
International	416	40
National	407	39
Sole trader	70	7
Number of employees		
1–50	190	18
50–100	93	9
100–250	134	13
250–500	111	11
500–1,000	86	8
1,000 plus	419	41
Organizational role		
Managers and senior officials	198	24
Professional occupations	337	41
Associate professional and technical occupations	227	27
Administrative and secretarial occupations	46	6
Skilled trade occupations	1	0
Sales and customer service occupations	10	1
Elementary occupations	1	0
Students	7	1

Analysis and Testing

The responses to the survey's 7-part Likert questions were analyzed using SPSS through standard statistical testing for reliability—the result being Cronbach's alpha = 0.937, (N = 85)—and validity, as well as their support for the hypotheses.

As this survey data was difficult to generalize across times, etc., this analysis was mainly concerned with internal data validity, tested through content—the extent to which the data provides adequate coverage of the investigative questions that guide the study (Blumberg et al. 2008). Significance through nonparametric means was clear—this was not a standard bell curve of data distribution, and therefore use of the chi-square test was indicated for nominal data. In Table 1, we see the percentage and rating average level of agreement for each of the questions testing our strategic hypotheses where 1 was "strongly agree" and 7 was "strongly disagree," with 4 as "no view."

Table 4 Responses description per section

Section	Number of questions	Type of data	Responses	Missing data (%)	MCAR test (sig.)	Observations
1: Organizational background	5	Nominal	1,034	6	NA	
2: About you	7	Nominal	930	28	NA	One optional question
3: Organizational practices	26	Scalar	806	1	.911	
4: Communities of practice CoPs	22	Scalar	146	1	.514	
5: Leadership	24	Scalar Nominal	189	9.1	.980	Gender and nationality questions
6: Additional Organizational details	20	Scalar Open	149	7.2	.601	Two open questions
Total survey	104		1,034			

How to Form and Operate Communities of Practice (CoPS)

In this section, we provide a summary of our findings that managers can use in managing knowledge in their organizations by using CoPs. Every finding reported is based on correlations significant at 0.01 level (2 tailed).

The Knowledge Management Function

Our survey results show that for the knowledge management function to work quite satisfactorily, the organization has to have a clear map of where the knowledge is located and who holds it. The organization must have a policy in place that links the ability and willingness to share knowledge with reward. Working in CoPs should be an expected practice in the organization, and it should use CoPs to enhance individual knowledge. Change should be normal in such organizations, and CoPs should support new ways of working.

The knowledge management function has to work satisfactorily in the organization for employees to work and work together in CoPs as a matter of normal practice and support the development of new working practices. This will also give the organization a clear map of where knowledge is located and who holds it. A knowledge management program results in people working together in communities of practice (CoPs) that operate as described in the section on CoPs to follow.

Types of Communities of Practice

Manager-Run Formal CoPs

Manager-run CoPs are formal structures in organizations set up by management. In this case, the employees are happy to share their knowledge within their department but not outside of it, and they convey that the ability to easily access other people's knowledge has made them less creative. Manager-run CoPs can bid for resources for CoPs but have to achieve targets in return.

CoPs for New Product Ideas

To have new product ideas come from their CoPs, organizations use them to develop new organizational knowledge and expect them to produce outcomes. They allow their CoPs to develop new working processes, partner with CoPs in their allied/partner companies, and share the development of new products or processes with CoPs in their partner organizations.

CoPs for Innovation (CoInv)

CoPs support the development of innovation in their organizations by developing new working processes, giving new ideas for products, developing new knowledge, and giving their management the expectance of producing outcomes. They support the development of innovation by partnering with CoPs in their allied/partner companies and sharing the development of new products or processes with CoPs in their partner organizations. Their support for innovation in their organization comes because they can bid for resources for their CoPs but have to achieve targets in return.

CoPs for New Working Practices

CoPs to support the development of new working practice are used when employees use CoPs to enhance their individual knowledge, working in CoPs is expected practice in the organization, and employees set up their own CoPs and choose to work in CoPs as a matter of normal practice and develop their own working language. These CoPs support the development of innovation in our organization. Change becomes normal in such organizations, and they support new ways of working. These CoPs support the development of new organizational knowledge and innovation and new ways of working by making change normal in these organizations. They develop new working processes and bring new ideas for products. Management expects these CoPs to produce outcomes and supports them with resources and has a policy in place that links the ability and willingness to share knowledge with rewards.

These CoPs partner with CoPs in their allied/partner companies and share the development of new products or processes with CoPs in their partner organizations.

Setting up CoPs

Based on the results of our survey, with a 99% confidence interval, the participants state the following will set up successful CoPs:

CoPs Will Develop Innovation if Change Is Normal in Organization

When change is normal in their organization and their CoP supports new ways of working, then CoPs allow employees to set up support for the development of innovation through developing new working process and new organizational knowledge; and come up with new ideas for products by partnering with CoPs in their allied/partner companies; and sharing the development of new products or processes with the CoPs in their partner organizations. Management expects these CoPs to produce outcomes and supports them with resources and allows them to bid for resources, but they have to achieve targets in return.

Make Working in a CoP an Expected Practice

When working in CoPs becomes an expected practice in an organization, then its employees choose to work in CoPs as a matter of normal practice and use CoPs to enhance their individual knowledge; additionally, the management expects CoPs to produce outcomes. Employees are allowed to set up their own CoPs and work normally together in them, and then they use CoPs to enhance their individual knowledge. While management expects CoPs to produce outcomes, CoPs can partner with allied/partner companies. Change in these organizations becomes normal, and CoPs support new ways of working. These organizations have a policy in place that links the ability and willingness to share with rewards. Employees bid for resources for their CoPs but have to achieve targets in return. CoPs are used by these organizations to develop new knowledge. CoPs support the development of innovation in the organization, develop new working processes, and come up with new product ideas. These organizations share the development of new products and processes with CoPs in their partner organizations. These CoPs develop their own working language.

Let Employees Set Up Their Own CoPs

When organizations allow employees to set up their own CoPs, CoPs develop new working processes; support the development of innovation in the organization; and develop new organizational knowledge; and new ideas for products come from these CoPs.

Make Working in CoP a Normal Practice

Organizations can create working in CoPs as a matter of normal practice by allowing employees to set up their own CoPs; allowing them to partner with CoPs in allied/partner organizations; supporting CoPs with resources; and having a policy in place that links the ability and willingness of employees to share knowledge with rewards; and permits employees to bid for resources for their CoPs in return for achieving targets. They can share the development of new products or processes with CoPs in partner organizations. These CoPs develop new organizational knowledge and develop new working processes, as change is normal in these organizations. They support the development of innovation in their organizations which expect their CoPs to produce outcomes.

Management Set CoPs Work Against CoP Goals

Our survey finds that when employees want to set up their CoPs but are not permitted to do so or when CoPs are formed as formal structures set up by management, the employees never or rarely work in multidisciplinary teams and find it difficult to know people outside their departments; and often the rate of employee turnover is too high for any comprehensive mapping and structuring of knowledge to take place. By implication, such CoPs will be less likely to bring innovation.

Set Expectations for CoPs

Employees do not expect targets to be set for their CoPs when management has no expectation from their CoPs other than the sharing of knowledge, and also when the organizational culture is suspicious of knowledge sharing.

Expect CoPs to Enhance Individual Knowledge

When CoPs are used to enhance individual knowledge, employees choose to work in CoPs as a matter of normal practice, and CoPs develop new organizational knowledge and support new ways of working. Change becomes normal in these organizations.

Link Sharing of Knowledge with Rewards

When organizations have a policy that links the ability and willingness to share knowledge with rewards, then employees share the development of new products or processes with CoPs in their partner organizations; CoPs are used to develop new organizational knowledge; and employees must bid for resources but have to achieve targets in return. Management expects them to produce outcomes.

Have a Policy That Rewards Knowledge Sharing

If management expects CoPs to produce outcomes, then the organization must have a policy in place that links the ability and willingness to share knowledge with rewards and then the CoPs will develop new organizational knowledge.

Have Knowledge-Sharing Training and Events

If an organization does not have a clear knowledge-sharing training policy and events, then management should not have any expectation from CoPs other than the sharing of knowledge. However, the employees may read it as the organizational culture being suspicious of knowledge sharing.

Offer a Range of Rewards

When organizations have a range of different rewards to motivate employees to contribute there is personal knowledge to the collective repository, then employees understand that there is a policy in place that links the ability and willingness to share knowledge with rewards. The employees will normally work together and choose to work in CoPs as a matter of normal practice, and the knowledge management function works quite satisfactorily.

Provide a Formal KM Structure to Assist CoPs

When employees do not have a formal structure to assist them with knowledge management and they are left on their own to practice and learn, they do not have a clear knowledge-sharing training coming from policy and events.

Support CoPs with Resources

Organizational support for CoPs with resources results in their partnering with CoPs in their allied/partner organizations and supporting the development of innovation in their organizations. They are used to develop new organizational knowledge, and their management expects them to produce outcomes. They produce new working processes. They can bid for resources for themselves but have to achieve targets in return. New ideas come from these CoPs.

Let Employees Bid for Resources for Their CoPs

Organizations that let employees bid for resources for their CoPs in return for achieved targets expect CoPs to produce outcomes. They have policy in place that links the ability and willingness to share knowledge with rewards.

Allow Collaboration with Other Organizations

When employees enhance their own organization’s knowledge through involvement in collaborative working with other organizations, CoPs are used to support the development of new working practice, and they use CoPs to enhance their individual knowledge.

Operational Recommendations

Let CoPs Partner

Allowing CoPs to partner with allied/partner companies amounts to letting them share the development of new products or processes with CoPs in these partner organizations. This is how management can expect CoPs to produce outcomes, and CoPs are used to develop new organizational knowledge. Allow these CoPs to bid for resources for targets to be achieved.

Let CoPs Develop a Working Language

Letting CoPs develop their own working language results in CoPs developing new working processes and enables their managers to run their CoPs to develop new organizational knowledge. This is how change becomes normal in the organization: CoPs support new ways of working; partner with CoPs and share the development of new products or processes with their partner organizations, and so management can expect the CoPs to produce outcomes.

Formal CoPs

When CoPs are formal structures in organizations set up by management, they bid for resources for themselves but have to achieve targets in return and share the development of new products or processes with CoPs in their partner organizations. Such CoPs have limited contributions.

Conclusion

Contemporary organizations depend on knowledge for their success in the marketplace. Knowledge and its management are not just a concern of KM professionals but all employees. This redefines knowledge management for the purpose of organizing and managing the experiences of employees to ensure that they have the necessary knowledge when required. Thus, the KM function extends to efficiently and expeditiously creating, locating, capturing, refining, and sharing knowledge. In its new role, KM becomes a task for each employee, and those tasked with managing organizational knowledge become facilitators for this process, creating an environment that makes these employees creative and innovative. Voluntary groups for sharing knowledge, called communities of practice (CoPs), are created in organizations and become an answer to the above.

Based on a global survey conducted on 1,034 knowledge workers, managers, and senior executives from 76 countries, over a period longer than 4 years, we learned that CoPs can be good agents of change in all four forms we identify: manager-run formal CoPs, CoPs for new product ideas, CoPs for innovation (CoInv), and CoPs for working practices.

We find 15 guidelines for setting up CoPs. These guidelines cover the forming and setting rewards, sharing knowledge, partnering inside and outside the organization, resource allocations, management expectations, and training and training policy. We also provide recommendations for operating CoPs.

This new understanding on CoPs should help managers integrate workers who use knowledge into the function of knowledge management, as the role of knowledge management and managing knowledge workers (Amar 2002) are intertwined. One cannot look at one without looking at the other. Respondents of our survey tell us that through CoPs, they can contribute to the organization's knowledge management by bringing to use the knowledge they find in many places for their organization to exploit. Basic principles of CoPs suggests that employees at all levels of their organizations possess usable knowledge and the will to put it to work. The organization has to manage this knowledge in a new way and provide a suitable environment, through creating communities of practice, thus enabling employees to exploit this knowledge for the organization.

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Wenger EC, McDermott R, Snyder WC (2002) A guide to managing knowledge: cultivating communities of practice. Harvard Business School Press, Boston1 Only one known survey has more respondents, and that survey was not specifically a KM survey but had only a few KM questions included in it

Airport Technology Management

Dietmar P.F. Moeller

Introduction

Technology management in general can be introduced as a set of management disciplines that allow organizations to manage their technological developments in order to create competitive advantages. Typically the following major concepts are used in today's technology management:

- Technology strategy, focusing on the relevance of the technology used within the organization.
- Technology forecasting, focusing on the identification of relevant technologies for the organization, which can be achieved through technology scouting. Technology scouting relies on formal and informal information sources, including the personal networks of the scout (Rohrbeck 2010).
- Technology road mapping, focusing on mapping technologies to business and market needs.
- Technology project portfolio, focusing on a set of projects under development within the organization.
- Technology portfolio, focusing on the set of technologies in use within the organization.

Therefore, technology management became an explicit element in management practice and strategy which means management of what is well known and entrepreneurship which means creation and implementation of the new and/or innovation. Hence, continuous development of technology is valuable as long as there is a value for the clients, and therefore, technology management within an organization will be able to argue when to invest on technology development and when to withdraw.

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The Association of Technology, Management, and Applied Engineering (ATMAE) defines technology management as field concerned with supervision of personnel across the technical spectrum and a wide variety of complex technological systems. Technology management typically requires knowledge in production and operations management, project management, computer applications, quality control, safety and health issues, statistics, and general management principles (http://atmae.org). The complexity beyond this approach suggests that any organization has to master at the very first one level of technology before being able to proceed to the next complexity level. This is a major concern because the modern approach in marketing technology often results in the problem that the technology is being overhyped in the early stages of growth which can raise serious troubles in organizations. Therefore, organizations must decide on trustable technology management strategies to avoid wrong investments, cost-expensive redevelopments, time conflicts within the running business, etc. Against this background airport technology management (ATM) has to follow the foregoing-mentioned features running airports as competitive, cost-effective, on schedule, and safe civil air traffic facilities.

The extraordinary attribute running airports competitive was reason for the German Ministry of Economy and Technology to grant the joint research project "Competitive Airport" as part of the aviation research program 2007–2012 with the clusters:

- Ground/Taxiing Traffic Management and Optimization
- Landing and Takeoff: Interoperable Airport-Centered Traffic Management
- Turnaround Management

The cluster members of this research project are from airports, air traffic control, industry, and academic research institutes, representing the body of knowledge essential to accomplish the manifold of different topics. In case of the interoperable airport-centered traffic management local airport management has to deal with IT-based systems, which require an easy-to-understand technological solution with interfaces for seamless integration of the several and different IT systems, some of which can be generic, within the entire airport-centered traffic management, such as:

- Networked airport planning
- Optimization of ground/taxiing processes
- Transition to a flexible use of runways
- Wide area multilateration

Beside the foregoing mentioned IT-based systems the overall airport management also has to deal with the following IT-modules to enable clients to share centralized, up-to-date, and accurate real-time information, as well as run the airport business cost effective, on schedule, and safe:

- Airport terminal resource planning and management
- Baggage handling
- Energy saving systems

- Flight information display
- Flight information management
- Gate management
- Security systems

Airport Management

Airports are the most vital element within the air transportation system. Technology wise, they are well equipped and managed and provide a variety of facilities for aircrafts, aviation stakeholders, crews, and passengers. Airport facilities include runways and taxiways, lighted for day and night use; ramp/apron areas for aircraft turnaround processes; hangars for aircraft storage; maintenance areas for aircraft and avionics; one or more terminal buildings with airline check-in counters; airport security checking areas; passport control; lounge; restaurant and shop areas for passengers; car parking lots; and public transportation area. Most of the intrinsic airport facilities must be managed in an appropriate manner which requires a system which interfaces and integrates the majority of electronic information within the airport, assuring maximum flow of information for operations, management, and security providing an efficient, cost-effective airport operation. Due to the complexity of today's overall airport operation and management, airport management calls for total airport management system solutions (TAMS) consisting of various independent systems linked by high-speed fiber-optic cable to the overall airport control centers, the body that forms TAMS. In Fig. 1, the flight information display as part of TAMS is shown.

Some of the components of a total airport management system are (http://en.wikipedia.org/wiki/Total_Airport_Management_Systems):

- Air Traffic Control Administrator System
- Airport Landing Dues Information System
- Apron Services Management System
- Automated Warehouse System
- Facility Management System
- Flight Information Display System
- Gate Allocation System
- Ground Services System
- Handling Agent System
- Metrological Systems
- Over Flight Billing System
- Passenger Check-In System
- Point of Sale System
- Real-Time Apron Management System
- Security Systems
- Staff Information via Intranet
- Statistical and Financial Reports

Fig. 1 Flight information display as part of TAMS

Based on this approach, airport management can be in general divided into two major groups which contain the foregoing-mentioned subsystem features:

- Airport Information Management
- Airport Technology Management

Airport Information Management

The objective of airport information management is to provide airport management and other stakeholders with real-time information originating from interoperable and integrated IT systems at the airport by using a shared secure data warehouse approach as single data source. Therefore, airport information management covers a manifold of systems, a few of which are described consecutively:

- High-Performance Messaging System, capable to collect any kind of message from any available gateway and data source to automate the interface of the manifold of distributed airport applications like:
  - Air Traffic Control Gateway
  - APRON Gateway
  - Baggage Processing Messages
  - Flight Schedule Messages
  - Fueling Messages
  - Loading Messages
  - Movement Messages
  - Passenger Information Messages

Messages within the High-Performance Messaging System are stored in database management systems which allow searching, retrieving, and parsing based on the message type or any other type of key like airline code and flight number. They also allow interfacing with gateways.

- Operational Database Systems represent centralized, secure, and shared warehousing systems that consolidate all airport operational data in a single core database of the Operational Database System ensuring data and transaction consistency and easy sharing of data.
- Statistical Data Management Systems transform the raw operational airport data into dedicated management information which help to underpin decision making on:

  – Current and future airport operations and airport resource requirements
  – Current status evaluation of ground handling operations
  – Deployment optimization of existing airport resources
  – Future needs for additional airport resources in relation with the expected growth in the numbers of passengers and freight/cargo

The quality of statistical analysis pivotal depends on the availability of the operational airport data like:

– Baggage information: This means number and type of bags, availability of a fair number of baggage handlers and tug drivers to drop off and/or pick up baggage, availability of baggage carousels for arriving passengers, mishandling and irregularities of arrival and/or departure baggage, etc.
– Load information: This means amount of mails, cargo, crew, and passengers.
– Punctuality and regularity: This means flight delays and delay codes.
– Resources allocated to the flight: This means available check-in counters, available boarding gates, available baggage reclaim belt, etc.
– Times: This means scheduled times, estimated times, touch-down times, takeoff times, block-on times, block-off times, red times, zone-in times, boarding times, last call times, flight closed times, etc.

The complexity of these airport operations requires an adequate and efficient technological support to manage these processes running and/or adapting and/or planning airport resources in relation to an annually expected growth in passengers and freight/cargo.

One approach to support airport management in decision making is computational modeling and simulation, which allow identifying dependent relationships and the impact on the overall airport operating performance.

Computational Modeling and Simulation in Airport Passenger Information System Development

Computational modeling and simulation is an iterative process consisting of successive mathematical model building and computer-assisted simulation steps. A model can be manipulated in accordance with the scope of the simulation study by changing the model structure, model parameters, inputs, and outputs to accurately match the real-world system behavior. A derived model achieves its purpose when an optimal match is achieved between the simulation results, based on the mathematical model and data sets gathered through real-world system measurements and experimentation.

The use of systems theory for solving problems that overlap several scientific disciplines has improved cooperation among these disciplines and lowered previously rigid barriers between them. The most important step of systems theory is the translation of a real-world system into the mathematical language of systems theory, which is universal while independent from the area of concentration. Developing suitable models of real-world systems and a thorough understanding of the system under test and its operating range are essential. Consequently, a real-world system can be described using the respective mathematical notation, for which the mathematical model fulfills the essential requirements. More generally, a system is assumed to conform to this description if it contains the following items:

- Attributes
- Elements
- Relations

Based on logical assumptions, these items are part of a structure, called a system. Elements can be components, parts, and so on, while relations are cooperatives, couplings, etc., and attributes introduce properties, features, signatures, and so forth. Moreover, attributes provide connections between the system and the system environment. An attribute that describes a system condition is called a system state. Attributes that interact with each other are called system-related internal descriptions. Assuming that A is a nonempty set of attributes and a and B are nonempty sets of relations, a system description P can be defined as (Moeller 2003)

$$F := (\text{as } A, PgB). \tag{1}$$

The passenger information system model has to display accurate information on the status of the passenger at check-in in the terminal, security inspection, passport control – if not a domestic flight – and boarding, which can be modeled as workflow-based chain function that follows the FIFO queue approach as shown in Fig. 2 for the check-in counter.

The passenger information system model at security is a function based on FIFO queues as shown in Fig. 3.

For simulation studies, SimEvents can be used which allow an easy event-oriented modeling as shown in Fig. 4. From Fig. 4, it can be seen that the SimEvents library allows different intrinsic dynamic options for each block. In case of the passenger model at check-in, the passengers wait in a queue at the check-in counter. The intrinsic queue dynamic itself can be modeled as FIFO, LIFO, or a priority queue – like for business and first-class passengers.

Based on the design view developing a passenger model at check-in in Fig. 4, the SimEvents passenger departure/subsystem check-in counter is shown in Fig. 5.

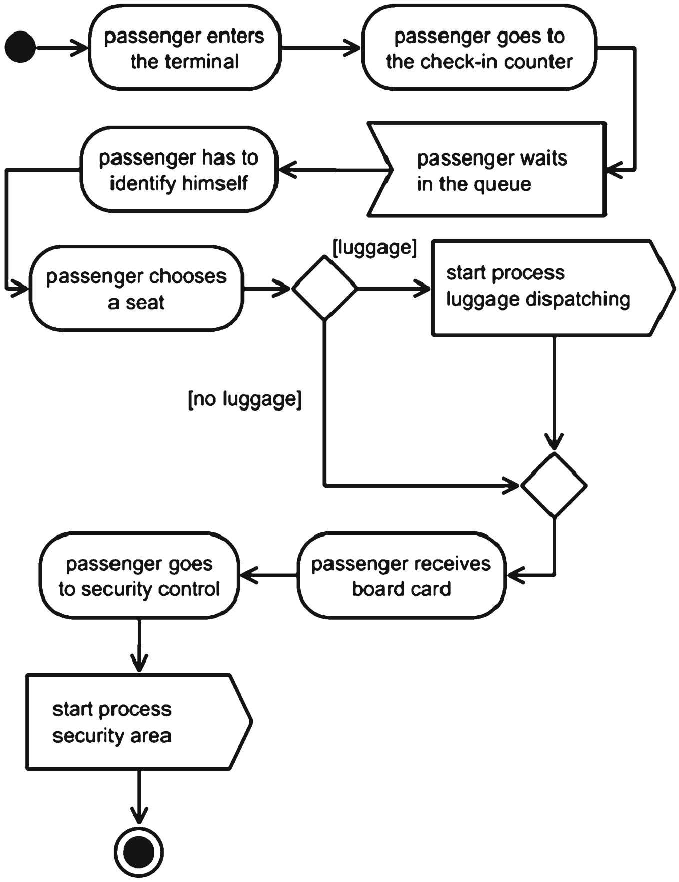


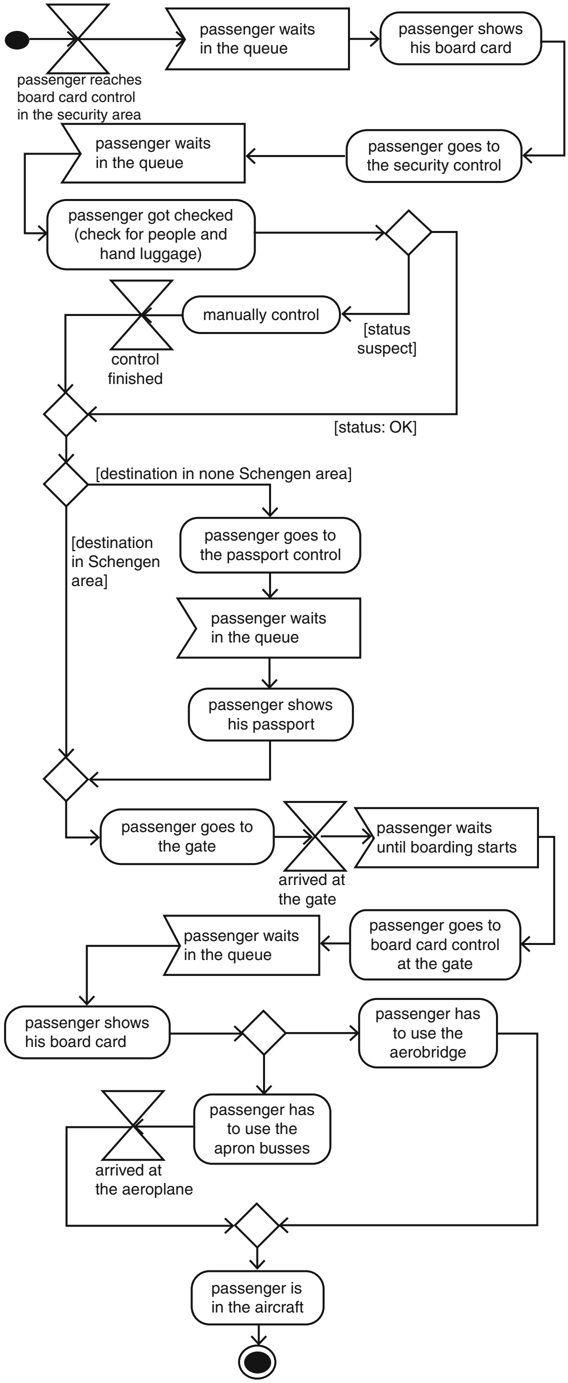
Fig. 2 Passenger at check-in

The revenue passenger emplacement for a 24-h day profile is shown from simulation results in Fig. 6. Based on such models, the resources required for growing passenger number can be estimated.

Airport Technology Management

Airports today are faced with a changing and competitive growing market in which technology provides an advantage; thus, technological awareness and management is a priority for airport short-, mid-, and long-term business. But how can airport technology management be characterized in this sense? It can be introduced as modular, reliable, secure, and stable functionality beyond old-fashioned systems and human capability helping proactively facilitating collaboration between airport

Fig. 3 Passenger at security



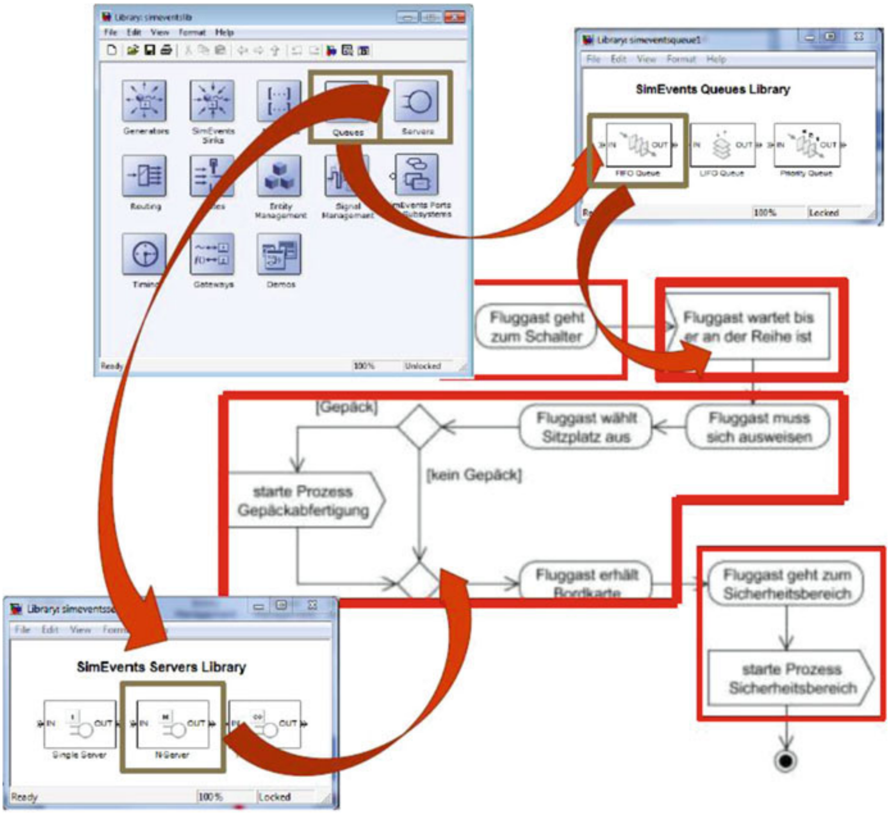


Fig. 4 Development of a passenger model at check-in

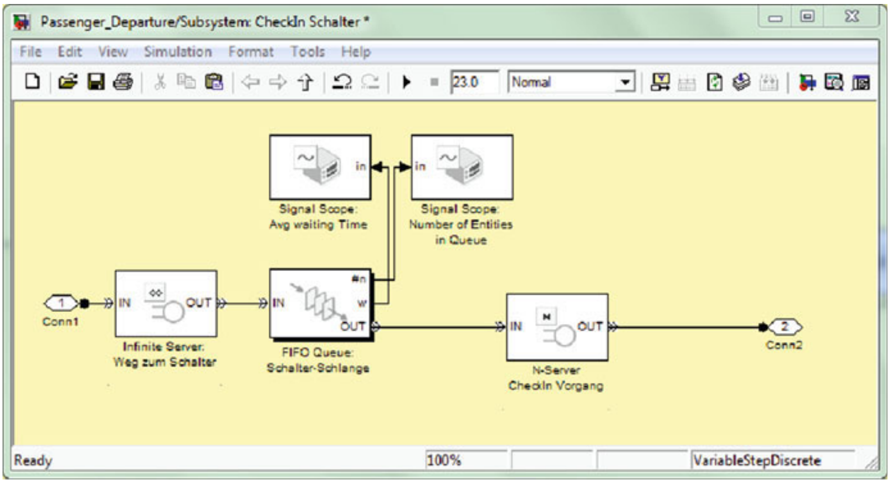


Fig. 5 SimEvents passenger model at check-in

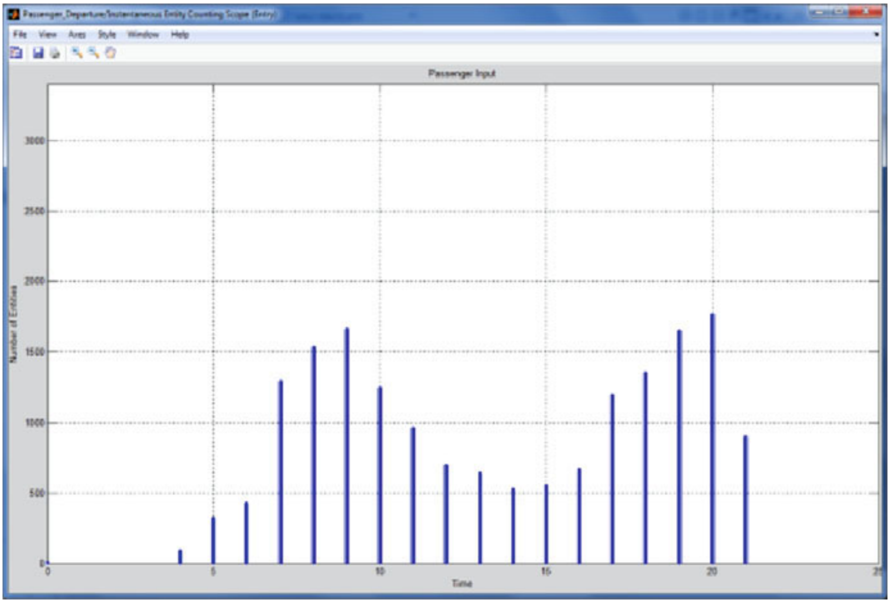


Fig. 6 SimEvents-based day profile of passengers at check-in

authorities, airlines, ground handling, and air traffic control within the airports in order to minimize operational failures. Airport technology management also enables managerial insight to plan and forecast future airport operations and ground handling resource requirements to capitalize on revenue potential and enhance service quality from the competitive perspective and avoid that airports become a bottleneck for air transportation.

From an international aspect, A-SMGCS (Advanced Surface Movement Guidance and Control System) is an essential airport technology to manage approaching and departing and taxiing at airport runways to guarantee:

- Safety with growing air traffic volume
- Utilization of airport capacities
- Efficiency of air transport

A-SMGCS consists usually of the following equipment (Loth et al. 2007):

- SSR (secondary surveillance radar) Mode S Multilateration System to localize and positively identify aircraft and vehicles equipped with squitter units.
- SMRs (surface movement radars) to localize all aircrafts and vehicles. Vehicles without cooperative equipment can be localized but not identified.
- ASR (airport surveillance radar) interface to ensure seamless tracking of approaching and departing aircrafts.
- Interface to flight databases to correlate A-SMGCS data with additional flight information in the identification process.

Table 1 Categories of scenario analysis

Best case scenario analysis	Worst case scenario analysis	Real case scenario analysis
Resources for ground handling are available; no shortage appears	*Resources* for ground handling not available in the required amount or at the worst only one resource is available but several of which are needed; shortages appear	*Resources* available for ground handling are well balanced. Cost of solution in between best case and worst case
Result: Costly solution, basically resources available cannot be used in an optimal way, because more resource available than necessary	*Result:* Cheap solution; available ground handling resources are not adequate	*Result:* Obtained solution for the real case analysis is suboptimal

- SDF (Sensor Data Fusion) to merge all data from all sensors into one data set for each individual aircraft or vehicle.
- Runway incursion detection and handling logic.
- Displays of traffic situation for several controller working positions.

Besides managing taxiing traffic at runways, a technology-based ramp/apron vehicle management is a major concern optimizing the turnaround process. Economic benefits for airports and therefore a better initial competitive position can be offered by technological systems for vehicle management on ramps/aprons which maintain an optimized turnaround process. Today ground handlers suffer under the economic pressure due to liberalization of ground handling services at (European) airports. Additionally, the competition between traditional and low-cost airlines results in a more efficient utilization of aircrafts which require shorter turnaround times. Shorter turnaround times can only be achieved when doing the same work in less time with better resource utilization, which is not easy to reach due to constraints which have to be fulfilled as shown in Table 1.

From Table 1, it can be seen that optimizing the ground handling process requires a turnaround process workflow which is less sensitive against disturbances such as delayed plane arrivals and bad weather conditions. This makes it necessary for ground handling services to embed the past, current, and coming involvement of individual ground handling vehicles in the turnaround process for decision making in the car management on aprons system approach. Moreover, ground services need status information and predicted schedules of the turnaround processes planning resource usage and utilization, based on the vehicle fleet. For steering purposes, vehicles ground services need appropriate means sending assignments to the individual vehicle drivers and getting acknowledgements from them. The large number of vehicles for ground handling to be equipped with communication tools requires inexpensive on-board units (OBU) which must render possible ad hoc installations for vehicles rarely accessing the airport. Obvious options for such OBUs are PDAs, smartphones, and tablet PCs commercially available with GPS for positioning and communication equipment like WLAN and GSM. The use cases for vehicle

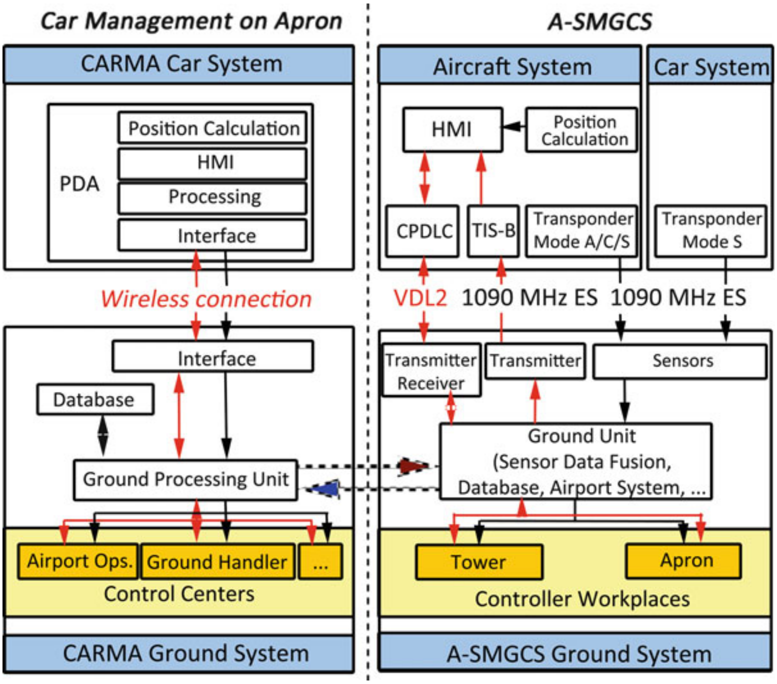


Fig. 7 Architectures of CARMA ground handling system and A-SMGCS

management on aprons can be implemented with the architecture used in the CARMA project as shown in Fig. 7 in comparison with the current A-SMGCS architecture (Loth et al. 2007), which both follow a similar architectural approach.

The main goal of the CARMA project was the development of functional models and prototypes, and an onsite evaluation in a real operating environment at Hamburg Airport. For these purposes, technologies for wireless communication, identification, localization, databases, and maps are analyzed, selected, and embedded in a prototype. The project was the first which benefits from a level 2 A-SMGCS which was installed in parallel.

In the near future, it can be assumed that the paradigm of the Internet of things (Yan et al. 2008) will make the foregoing airport technology management processes much more enhanced and easier to realize through pervasive computing. Pervasive computing or ambient intelligence allows services which are emerging as next generation for distributed and mobile ubiquitous computing, which is seamlessly available anywhere, anytime, and in any format. With mobile ubiquitous computing, computing is embedded in every object. Thus, ubiquitous computing allows embedding computing everywhere, in services such as:

- Human to human
- Human to machine
- Machine to human
- Machine to machine

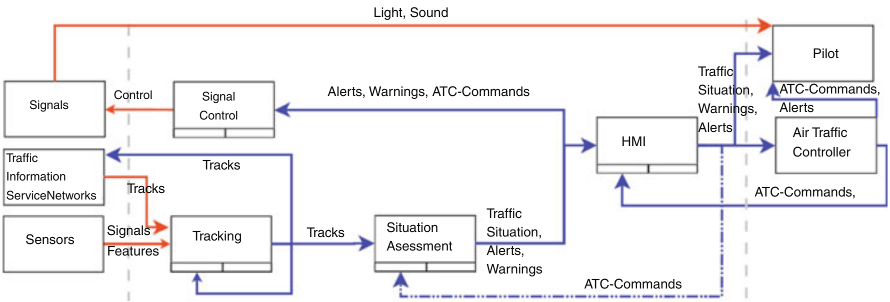


Fig. 8 Basic architecture of a runway incursion prevention system. The primary input to the system is provided by sensors and traffic information services and is imputted from air traffic controller (ATCO) and pilots via a human machine interface (HMI). From this information, the system assesses the traffic situation and provides warnings or alerts to pilots and ATCOs via air field lighting signals or HMIs (Schoenefeld and Moeller 2012)

Early forms of ubiquitous ICT networks are evident in the widespread use of mobile devices, the number of which worldwide surpassed 2.5 billion in mid-2010. These little gadgets become an integral and intimate part of everyday life for many millions of people, even more so than the IoT (Luo et al. 2008).

Beside airport car management on aprons, managing and optimizing taxiing traffic at runways is a much more technology and innovative-oriented intention. Runway incursion alerting is one of the key airport technology management issues for safe and secure taxiing at airports. Runway incursions are occurrences at an aerodrome that involve the incorrect presence of an aircraft, a ground vehicle, or a person on the protected area designated for the landing and takeoff of aircraft. The growing air traffic volume has kept avoiding runway incursions on the National Transportation Safety Board (NTSB) most wanted list for safety improvements for over a decade (Schoenefeld and Moeller 2012). In the past, runway incursions have led to accidents with significant loss of life. The worst runway incursion accident was at Tenerife, Canary Islands, Spain, in 1997, where two Boeings 747 collided. Recent incidents (Reuss 2009; NTSA 2009) show that runway incursions are still a problem. Although the number of runway incursions that result in an accident is small, the number of runway incursions has not significantly declined over the last decade. Statistics and results from simulation studies strongly indicate that the number of runway incursions increases much more rapidly than the traffic volume. Depending on the airport topography, an increase of 20% traffic volume may result in a 140% increase of runway incursion potential for a single runway (ALPAI 2007).

Runway incursion prevention technology is based on protecting measures against causes that lead to a runway incursion and providing alerts during the cause of a runway incursion. For example, safety logic could prevent air traffic control (ATC) from commissioning more than one aircraft to use the same runway, thus providing protection against this type of operational error. To achieve this, runway incursion protection requires removing the human from the loop as much as possible. Thus, the general architecture of runway incursion prevention technology looks like the architecture shown in Fig. 8.

The primary input to the system is given by information from various sensors and from traffic information service networks. This information is usually fused by multi-sensor data fusion, integrating background information such as maps and movement models into tracks describing the movements at the airport. This description is evaluated, and ATC commands such as route information are integrated to assess the traffic situation, to predict conflicts, and to detect runway incursions. Information about the traffic situation is given to ATC, pilots, and vehicles via a human machine interface (HMI), for example, an electronic flight bag (EFB) if available, and signals at the airport or via radiotelephony (RTF) are from an air traffic controller (ATC). The fact that the architecture communication of the distributed components belongs to the technology is important because a communication infrastructure to support high-speed data transfers from/to sensors and signals distributed across the airport are not always available. For example, the operation of intelligent signals on serial circuits requires the use of power line communication technology with sophisticated algorithms to ensure real-time constraint compliancy (Schoenefeld and Moeller 2012). Runway incursion prediction and detection algorithms are algorithms that are used to detect runway incursions in their early stages or to predict them before they happen. Often, dedicated areas/volumes on the airport surface and on the final approach paths are used to determine specific variables needed for the detection of a runway conflict.

Beside the vehicle sensor technology, specific airport sensors are part of the airport technology management infrastructure. One of the most important properties required by the sensors is that they work under challenging environmental conditions, for example, when the visibility of pilots and air traffic control (ATC) is limited. However, even sensors that are suited only for clear weather could prove to be useful because field studies found that the visual “out of the window” detection of runway incursions often fails or lags behind automated alerts even during the best weather conditions (Stevens and Sanchez 2010). The specific airport sensors that are part of A-SMGCS, an overall airport technology management system, are:

- Surface movement radar
- Low-cost surface movement radar
- Universal medium range radar
- Multilateration mode S radar

Conclusion

The present survey of developments in airport technologies and their management discusses the overall aspects in airport information and airport technology management from the perspective of a total airport management system which is of importance for airport extensions and upgradings, airport developments, polluter penalization, airport effects on environments, ground handling methods, and ATC. This chapter did not focus on duty-free sales at airports, the privatization of airport security, new alternatives in air-cargo handling, and the reduction of fuel consumption and emissions on the ground.

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Innovation and Implementation of Climate-Related Energy-Efficient Building Design in India

Reinhard Doleschal and Uta Pottgiesser

Introduction

In the next 40 years, the current world population will increase by 30%. Constantly shrinking resources and deteriorating environmental conditions are the core challenges of the global humanity. Therefore, population growth and the booming economy in emerging countries like China and India have a big impact of demand of natural resources and environmental change. As novel price winner Joseph Stiglitz stated, the rising power of Asian countries is at least the "correction of a 200-year historical anomaly, in which Asia's share of global GDP fell from nearly 50% to, at one point, below 10%. The pragmatic commitment to growth that one sees in Asia and other emerging markets today stands in contrast to the West's misguided policies, which, driven by a combination of ideology and vested interests, almost seem to reflect a commitment *not* to grow."[1] This rebalancing of economic power goes along with a high demand and supply of energy in China and India and other BRIC countries as well as with an acceleration of energy security, energy saving, energy efficiency, and renewable energy production. Energy efficiency as a core issue of sustainability offers immense opportunities for innovation-driven economic growth and prosperity. India's middle class will grow from nearly 150 million people today to nearly 600

[1] http://www.project-syndicate.org/commentary/the-perils-of-2012

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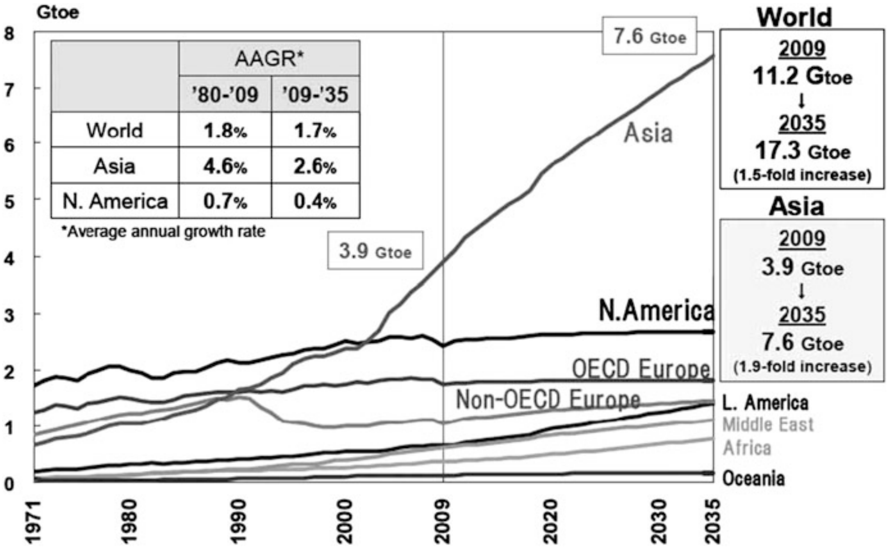

Fig. 1 Energy growth rate of OECD and non-OECD countries (IEEJ 2011)

million (50% of total population) by 2030.[2] But most importantly, it is an enabler for combing science and business with sustainable economic development and societal interest. Population explosion, environment degradation, and paucity of all kinds of resources elevate high local and global risks, but all the risks involve themselves in infinite opportunities for sustainable based businesses and corporate social responsibility.

This chapter investigates the relevance of buildings and constructions in terms of energy consuming and issues of energy efficiency combined with living comfort in a historical perspective. Today, buildings account 40% of the total US energy consumption[3]; in India it is estimated by 30% of the total energy consumption.[4] Depending to the growth of the building sector, this share will increase extremely. Advisers reported that "by 2025, buildings worldwide will be the largest consumers of global energy – greater than the transportation and industry sectors combined."[5]

Statistics show that the total energy demand of Asia (including China and India) will be nearly doubled within the next 25 years and so exceed by far that of the other continents (Fig. 1).

However, the most important point is the gap in developed countries and in emerging economies between challenges on energy efficiency living, awareness of

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[2] McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth. (http://www.mckinsey.com/insights/mgi/research/urbanization/urban_awakening_in_india)

[3] http://newscenter.lbl.gov/feature-stories/2009/06/02/working-toward-the-very-low-energy-consumption-building-of-the-future/

[4] Vivek Gautam (2009). Energy Efficiency in Buildings: Indian Market Landscape. (www.frost.com)

[5] http://www.clearpathsus.com/articles/buildgreen.html

energy saving, institutional learning and education on these fields, research and development, and last but not least implementation of best practices in public and private areas and in residential and commercial buildings.

Nevertheless, usually there is no transfer of knowledge and design specifications from the design phase to operations. Very few new buildings are planned in a comprehensive life-cycle model, and most building facilities management staff do not have access to the design specifications of building systems they maintain.

When buildings are designed so that their systems work together to maximize energy efficiency, they can use less energy than they do on average today, even as they provide heating, ventilation, air-conditioning, and lighting, together with power at the electrical outlet. For this enhanced performance level to be achieved, the building needs to be constructed according to environmental specification.

This chapter is a first outline of a long-term joint research project between Germany and India on innovation and implementation of climate-related energy-efficient building design. We thank all Indian and German partners, namely, the International Bureau of BMBF, the Indian Institute of Science (IISc), and Bayer Material Science (BMS) for the great support and fruitful collaboration.

Climate-Related State of the Art in Energy-Efficient Buildings

Research and praxis in architecture and building industry have developed many technological and material solutions within the last decades. In Europe, the energy saving became a crucial aspect after the oil crisis in 1973; regulations for buildings started in the 1980s and have been further developed and sharpened until today. The European Union's Directive on the Energy Performance of Buildings from 2010 has now introduced the standard of the "nearly zero energy building (ZEB)" that has to cover a "significant amount" of its energy demand by renewable energies "on-site or nearby" as a European standard to be realized until 2020. The future of energy-efficient buildings will be the standard of plus energy buildings that are producing more energy than they demand themselves. This will be a paradigm change with huge impact the grid structure and the energy-providing system that will be answered differently in certain countries.

The certification of buildings has become common practice to label the buildings; still different and competing systems appear worldwide: BREEAM, LEED, GREENSTAR, Cradle to Cradle, DGNB, and more. The approaches differ in content and weighting of the factors and cannot directly be compared. Most of them are not dealing with embodied energy and life-cycle assessment but focus on energy consumption in operation of the buildings. As for India, the need of energy saving is described in different documents, among them the Energy Conservation Building Code (ECBC) from 2007 and the ECBC User Guide from 2009 (BEE 2007). Also in 2007, the LEED certification has been introduced by the Indian Green Building Council (IGBC) to raise awareness and to reduce energy consumption (IEA 2011). Finally in 2010, the Green Rating for Integrated Habitat Assessment (GRIHA) has been introduced as the National Rating System and a tool to design, operate, evaluate,

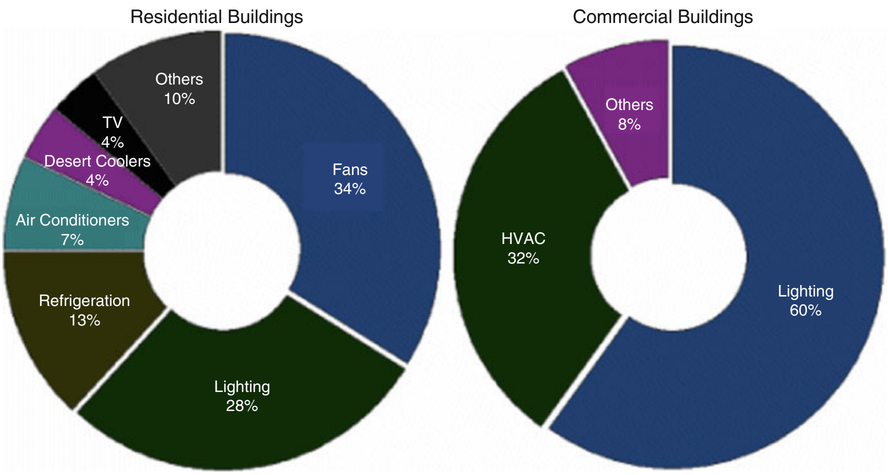

Fig. 2 Energy consumption of residential and commercial buildings in India (BEE 2009)

and maintain green buildings over all climate zones and building typologies (IGBC 2007).

Nevertheless, 40% of the total energy consumption worldwide is linked to buildings, mainly used for cooling, heating, and artificial lighting; fans and water heating are specific. Further distinction can be made between residential and nonresidential buildings and industrial plants. It is obvious that residential buildings show an increasing demand of energy owing to the improvement of quality of life in the middle class and also the implementation of minimum standards for the poor (Fig. 2).

The McKinsey Global Institute estimates that the most cost-effective measures taken to reduce greenhouse-gas emissions involve building efficiency (MNRE 2010). The measures are:

- Building insulation
- Lighting systems
- Air-conditioning
- Water heating

Looking back into history, India has a rich tradition of climate-adapted buildings that worked properly. Many scholars in India are aware of those qualities and principles and want them to become part of future-oriented design strategy in architecture and building construction (McKinsey Global 2010). Related to its five climate zones, different forms of architecture, materials, orientation, and principles can be found – most of them are perfectly adapted to the climatic requirements and in local building materials (Fig. 3).

In the eighteenth and nineteenth century, a period of colonial British architecture is characterizing part of the different Indian state capitals before all New Delhi with its public buildings such as train stations, colleges, museums, and monuments.

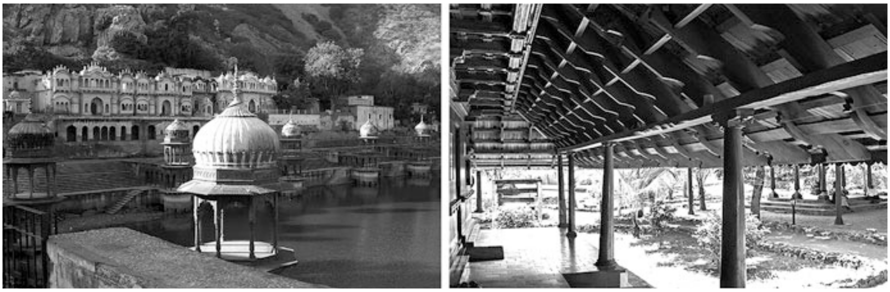

Fig. 3 Traditional tropical architecture of the last centuries was aware of the importance of solar shading in combination with natural lighting and ventilation. Depending on the climate zone, massive or wooden construction was preferred

Fig. 4 Modern tropical architecture is very present in India since the 1920s using traditional principles with new materials and in another formal languages; examples are residences in Mumbai and the buildings in Chandigarh

Those are primary representative but they are not showing specific of climate-related characteristics. More interesting in this regard is the huge amount of modern movement buildings that, for example, in Mumbai, can be compared to the famous Art Deco building stock in Havana (Cuba) or Miami (USA). In many cities, large-scale residential complexes from the 1930s are still in use – marked by overhanging balconies and horizontal brise-soleils (sun protection). More importantly, they are part of a human-scaled urban infrastructure offering private and public spaces in transition and in combination with trees and plants. After independence in 1947, more public, administrative, and governmental buildings followed in the tradition of the modern movement. Most famous is the capital of Chandigarh as a completely planned city (Figs. 4 and 5).

Urban and architectural planning in India will have to rise to the challenges of improving the building stock and new buildings at all levels with energy-efficient structural and technical measures. In the case of the building stock, the field of operation is of course reduced compared to new buildings. Orientation, plan, and

Fig. 5 The design of the facade and of solar shading is a crucial factor for the climate control and the energy-and cost-efficient design of buildings on the construction side

Fig. 6 Most Indian megacities are characterized by the uncoordinated superposition (overlay) of architectural and infrastructural elements owing to the fact of extraordinary and rapid growth

facades allow only limited interventions and have to be verified in every single case. Lighting, cooling/heating, and the use electronic devices are highly depending on the user's awareness (Fig. 6).

The measures for implementation have to be applied at different levels of the planning and building process (urban, constructive, and technical) and in the operation of the buildings. The user's comfort is the main issue to obtain acceptance and create identification with a building. Their behavior is a crucial part to realize an optimal operation of the buildings. The following table compares the most important measures (Table 1).

In any case, the implementation of energy-efficient technologies in buildings has to go along with a nationwide educational campaign. Next to the improvement of the building stock, it is of highest priority to ensure and to improve the quality of life, the provision of water and electricity, and the disposal of water and waste.

Table 1 Measures at urban, constructive, technical, and operating levels to ensure energy-efficient buildings

	New buildings	Building stock
Urban measures	1. Respect building tradition	1. Elaborate traditional elements
	2. Orientation for wind and shading	2. –
	3. Interaction with ecosystem	3. Reactivate or create if possible
	4. Provide private and public spaces	4. Modify or adapt if possible
	5. Zoning according to usage	5. Modify or adapt if possible
Structural measures	1. Insulation (preserve, heat, or cool) (suitable for all building elements)	1. Insulation (preserve heat or cool) (suitable for roofs and part of walls)
	2. Storage mass – water cooling (massive construction – cooled air)	2. If possible
	3. Sun protection – solar shading (prevent overheating + direct sun)	3. Retrofitting possible
	4. Natural daylighting – light control (allow indirect solar radiation)	4. Retrofitting possible
	5. Natural ventilation (conduct heat and moisture away)	5. If possible
Technical measures	1. Minimizing electrical consumption (energy-efficient lighting + appliances)	1. Minimizing electrical consumption (energy-efficient lighting + appliances)
	2. Producing renewable energy (photovoltaics, wind)	2. Producing renewable energy (Photovoltaics, wind)
	3. On-site heat recovery (Solar thermal, heat pump, combined heat and power)	3. On-site heat recovery (solar thermal, heat pump, combined heat and power)
	4. On-site cooling (absorption/ compression cooling)	4. On-site cooling (absorption/ compression cooling)
	5. Mechanical ventilation (with heat/ cooling recovery, foster cross ventilation/exhaust-air extraction)	5. Mechanical ventilation (with heat/cooling recovery, foster cross ventilation/exhaust-air extraction)
User behavior	1. Knowing and applying energy-saving measures	
	2. Maintenance and service have to become a routine	

Population Growth in India and Energy Demand

In the next 20 years, India has the fastest growth in population from nearly 1.2 billion people by 2011 to nearly 1.5 billion people by 2030. As the McKinsey forecast[6] in a trend report for India shows, accompanied with this demographic trend are sprawling suburbs and migration from remote rural areas to metropolitan regions for better choices of work, income, and living standards (see Fig. 7).

[6] McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth

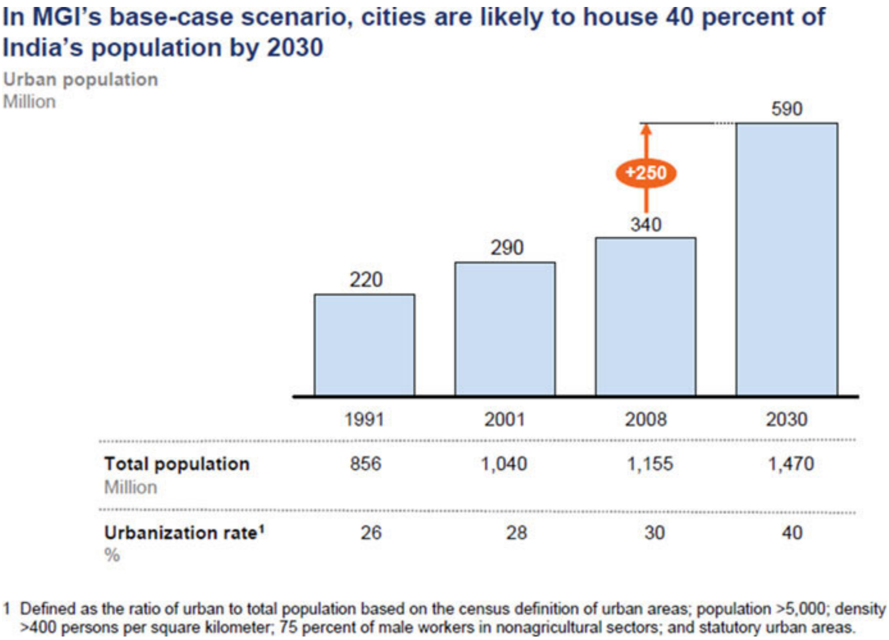

Fig. 7 Population in Indian cities in 2030 (MGI (2010). India's urban awakening: Building inclusive cities, sustaining economic growth)

This population growth in urban areas and the rapid increasing middle class accelerate a growing demand on goods, material, and different types of energy. In 2030, nearly 70% of the GDP will account by cities all over India. The compound annual growth rate will be nearly 8%. In 2030, about 40–50% of the energy demand by non-OECD countries is coming from China and India. The share of energy demand by buildings (construction and operation) in India will rise from currently 30 to 40% of the total amount. On the base of a strong governmental energy-saving and efficiency policy and regulation as well as an ability, affordability, and accessibility, India can save between 40 and 50% of energy demand and growth in the future (Fig. 8).[7]

In all natural resources, India has a lot of technological, financial, and governmental constrains to explore, procure, and supply these resources. Without international collaboration and domestic development of energy-efficient frameworks and instruments, the energy demand will not be supplied. High-energy efficiency buildings and on the edge operations can reduce the energy demand dramatically. Buildings can change from the energy consumer to an energy producer; it is time for zero plus buildings. Buildings like that produced more energy than they consumed (Fig. 9).

[7] IEA (2011). World Energy Outlook 2011

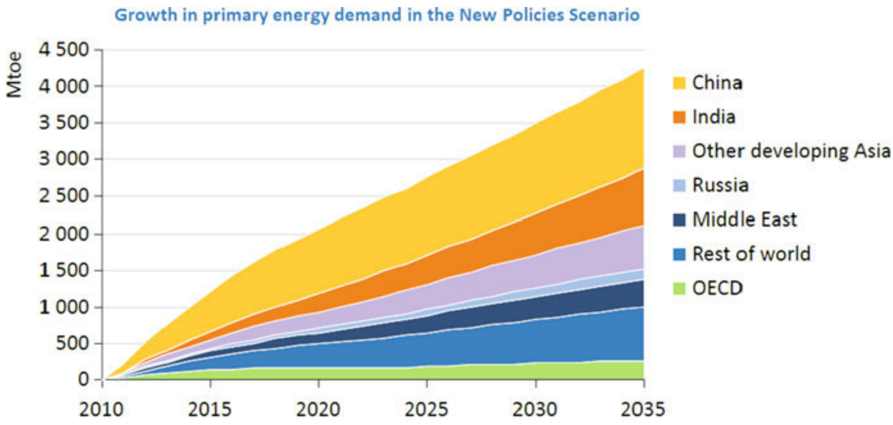

Fig. 8 World primary energy demand in China and India and ROW (IEA 2011. World Energy Outlook 2011)

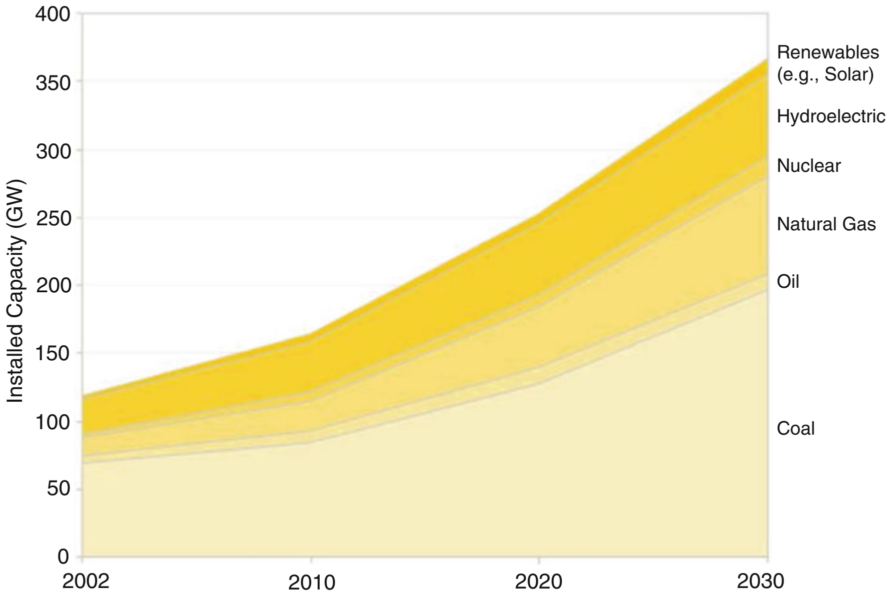

Fig. 9 India's installed energy capacity 2002–2030 (IEA 2004. World Energy Outlook 2004)

Growing Awareness of Energy Efficiency in India

As we guess, the higher educated middle class in India with increasing income and international experience has a high interest and demand of environmental protection and energy-saving actions. They want comfortable living in their residential, clean air in the city, comfortable transport systems, and world-class equipment of energy

Good cities deliver robust economic growth, as well as a sustainable quality of life

	What good cities deliver	
Robust economic growth	Sustained productivity advantage	▪ Cities have established a robust economic growth agenda and provide a favorable investor climate
	Robust job creation	▪ Ensures creation of sufficient jobs and livelihoods
Sustainable quality of life	Scaled public infrastructure	▪ Uninterrupted access to clean water supply for every resident ▪ 100 percent coverage, proper treatment of sewage and solid waste ▪ 45 minutes maximum intra city travel time for all citizens
	Reliable social services	▪ Quality, affordable education and health care facilities for all ▪ Access to affordable housing for all sections of the society; no urban slums
	Good recreational and community infrastructure	▪ Parks within 15 minutes of walking for every resident ▪ Open spaces throughout all cities ▪ Entertainment hubs and community spaces that celebrate diversity and foster innovation for all residents
	Sustainable environment	▪ Preservation of natural resources and ensuring access to clean air, water, and land ▪ Matching national standards on climate change, emissions, and sustainability

Fig. 10 *Robust economic growth and sustainability in good cities* (McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth)

saving in their new or old houses. At the moment in India, one can observe a massive trend in the upper middle class to move with family in new houses in the suburbs.

For that, the McKinsey report figured out criteria for robust economic growth and sustainable quality of life in cities (Fig. 10).[8]

Unfortunately, all these expectations and guideline stand in opposite to the quality of life trends from the same report.[9] From water supply to sewage, solid waste, private transportation, rail-based mass transport, and affordable houses, all these good infrastructure needs could be deteriorated without effective interventions (see Fig. 11).

Education and Training in Energy Efficiency

A key point of sustainability, environmental protection, resource effectiveness, and renewable energy production and supply is education and training of young people. From the "kindergarten" until the high schools and universities, methodological and

[8] McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth

[9] McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth

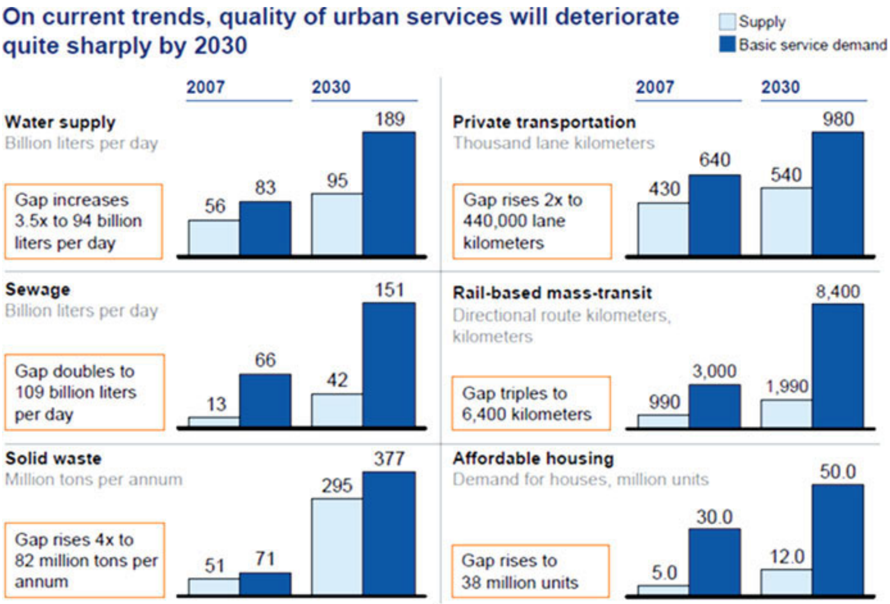

Fig. 11 Quality of urban services will deteriorate till 2030 (McKinsey Global Institute (2010). India's urban awakening: Building inclusive cities, sustaining economic growth)

didactical concepts have to be developed. Schools, colleges, and universities must be an enabler for energy-efficient living and environmental protection. A school – in visionary sense – is a building which has four walls and the future inside. A "green learning environment" is an energy-efficient, higher performing school that can be environmentally beneficial, economical to build and operate, and offer improved learning environments and labs for applied sustainability. Public school facilities are increasingly designed and constructed to be efficient, effective, and sustainable for their expected building life to enhance energy efficiency and environmental awareness. The actual student competition of the Indian Green Building Council (IGBC) for a sustainable school is a starting point of detailed discussions on buildings, spaces, products, and user's needs for a successful implementation of measures for the improvement of life conditions. Students from Deenbandhu Chhotu Ram University of Science and Technology, Murthal/Sonepat, and Ostwestfalen-Lippe University of Applied Sciences, Germany, have made several design interventions for sustainable schools. The next step is to realize a school pilot project on the edge.

Looking around in India, there are already established first pilot schools for sustainability. These schools are Auroville (Suhasini Ayer Guigan); The Doon School (Kothari and Associates); Delhi Public School, Agra; Vidyanidhi Education Society, Gurgaon; The Shri Ram School, Gurgaon; Salwan Public School, Woodstock School; Mussorie (Ar Niraj Manchanda); Druk White Lotus School, Leh (Ove Arup); Green Schools Program, CSE; Mirambika, New Delhi (Ar Sanjay Prakash); Shikshantar, Gurgaon; Pragyan, Greater Noida (Ar Sanjay Prakash); and Earth School, Jalandhar

(Ar Sanjay Prakash). These identified pilot schools in India must be evaluated and analyzed to design new innovative ideas for further facilities and applications.

Research and Development in Energy-Efficient Buildings

To accelerate the change process in the Indian energy efficiency scheme, it is helpful to have a look to the European and other Western societies. Innovation has become a key factor of European economy, research, and society. Upcoming research programs in Europe are created to react "in this the second decade of the twenty-first century, on the backdrop of a changing world order, (in which) Europe faces a series of crucial challenges: low growth, insufficient innovation, and a diverse set of environmental and social challenges" (MGI 2011). Many specific calls are related to the building sector looking for holistic approaches to combine the so far developed technologies within consistent building concepts. The well-being of the users is another focus to be considered to guarantee acceptance and so the efficient use of the applied technologies. Not only in India but everywhere in the world cost-effective solutions for the energy-efficient design of buildings and cities are needed. The existing innovations in architecture have to be transformed into innovation architecture.

For private and public organizations, one well-known approach to identify the best solutions is the method of construction radar to match, verify, and evaluate the different options according to the climate zones and building typologies. It allows to compare existing technologies, materials, or concepts and to visualize the potentials. The radar could give further input to the development of a strategy for the implementation of energy-efficient buildings (Fig. 12).

Construction radar is an operational instrument of Bayer Material Science (BMS) for strategic research, development, and daily business to identify short-term and long-term trends in material, application, technology, and market conditions. Each of these four radar segments is shared in four subsegments. In each segment and subarea, different trends must be identified for the next 3, 8, and 18 years. Between each short-term and long-term trend or aspect exists mostly a strong or slight link to each other. Through this combination and analysis, the stakeholder or interest group can assemble a development and marketing strategy and action plan. The following user survey should help to identify these trends and market demands from the costumer's perspective.

User Survey on Energy Consumption in Living

The transnational and transcontinental sharing and dissemination of knowledge in the field is as well important and can only be improved with the help of diverse stakeholders – including science, politics, and industry. For that, all stakeholders and guests can join the CREED-PS website http://www.hs-owl.de/creed/ to find further information on climate-related energy-efficient development.

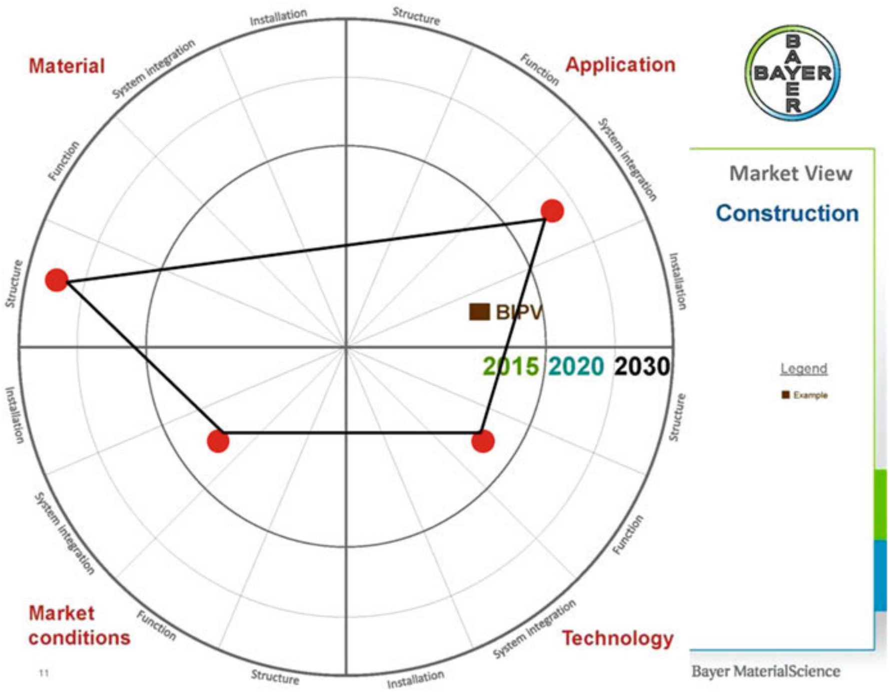

Fig. 12 The technology radar could be applied to identify and visualize the best solutions for energy-efficient buildings (BMS-Chart adapted by author)

As well the CREED-PS project provided an investigation of people in five Indian cities to explore the awareness and needs of the stakeholder. People of the city of Mumbai, Bangalore, Chennai, Delhi, and Pune can attend the investigation on the questionnaire at http://www.hs-owl.de/creed/events/investigation/.

Overall aims of the investigation and survey are:

1. To integrate the stakeholder's mindset in knowledge sharing and decision making on energy-efficient buildings and living style
2. To extend the awareness and the knowledge on energy-efficient building design
3. Identification of awareness/needs/methods/approaches to improve the Indian energy scheme
4. Development of instruments for the promotion of sustainable consumption such as new material, comparative testing, and awareness campaigns; life-cycle assessment; and green public procurement
5. Involving businesses and corporate social responsibility for the promotion of energy efficiency and sustainable consumption
6. Identification of a stakeholder strategy for energy efficiency and sustainable consumption

For the questionnaire, we designed following hypothesis:

1. Higher educated people of the new middle class in urban areas have a clearer awareness and higher needs on energy-efficient lifestyle than lower educated people.
2. Females are better informed on energy saving and efficiency than males.
3. Younger dwellers are better informed on energy saving and efficiency than older dwellers.
4. Living in the city center has a higher priority than living in the suburbs.
5. A good residential place has a higher priority than the distance to the working place.

The investigation design included a questionnaire with 22 questions within individual profile data on age, sex, and qualification. In the first section, data on mobility are explored. In the second section, data of housing and lifestyle are investigated. In the third section, data of living preferences, environmental aspects, and general topics are diagnosed. In each city, at least 200 questionnaires are collected. The evaluation would make with SPSS and EvaSys. The duration period is April 2012 till January 2013. After each city investigation, part results are delivered. In 2013, the final report will be finished and published on the website above.

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Between Collaboration and Competition in Modern Technology Management and Innovation

Peter Sachsenmeier

Executive Summary

This chapter promotes the discussion about the impacts of technological innovations on technology management and its future trajectory and also takes into account socio-economic dynamics.

From make-buy-ally to cloud, the conflict between having to compete and the need to collaborate continues unabated. However, the complexity and challenges of collaboration have increased, commensurate with various simultaneously coexisting powerful business models in today's global business world.

These contemporary business models require a radical rethink in the way technology is managed. All of them redefine the boundaries and locus of the firm. It is useful to distinguish between product and process innovations. The bottom line, that is, profitability, requires constant attention. Open innovation, user-led innovation, automated environments, and cloud business coupled with mobility each need different techniques and responses to ensure the survival of individual organisations and firms. Different models and responses are analysed and discussed in their contexts and the implications for technology management outlined in detail. Collaboration and innovation are central themes. It emerges that technology management has an exciting and extremely challenging future ahead, however, with many research questions as yet unanswered.

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While trust continues to be a paramount value for the functioning of collaboration in technology management, governance – that is, the exercise of power and control – must be achieved in new ways too, including the proactive and dynamic use of influence rather than authority.

New Business Models Require New Responses

Ten years ago, the European Engineering Association ewf brought together major industrial players from manufacturing to take stock of the status of collaboration and competition in the manufacturing industries which then felt on the threshold of new forms of collaboration (Sachsenmeier and Schottenloher 2003). At the time, the industrial landscape in the automotive and aircraft industries was already replete with alliances, strategic partnerships, and collaborative networks of excellence all intended to manage increasingly complex partnerships. These partnerships were primarily formed so as to achieve competitive advantage, shorter development cycles, and innovation.

Today's plethora of business models ranges from make-buy-ally to cloud, yet many of the questions posed then remain relevant today:

– How will companies manage the complexities between being in competition on the one hand and striving for partnership on the other hand, in practical terms?
– How will companies position themselves strategically in new networks in order to survive?
– What tasks and roles can be adopted by management and staff in the newly emerging networks?
– What are the new value systems in these networks? How do we achieve trust, openness, transparency, and fairness?

Ten years later, a number of tectonic changes have occurred, namely:

– Pervasive globalisation (a) of sourcing, innovation, markets, and supply chains, coupled with an always-on economic and social world
– Open innovation (b), as anticipated, linked to a preference for open systems with diverse partners
– Crowdsourcing (c) of talent and technologies created through social media and other channels, ranging from ideas to financing, and linked to terms such as *user innovation* or *mass innovation*
– M2X sensors (d), cyber-physical systems, and self-managing intelligent environments
– Cloud and mobile businesses (e), both of which change all models again

These tectonic changes pose new and extraordinary challenges for global collaboration and competition, especially in technology management and its pinnacle discipline, innovation. All of these approaches redefine the boundaries and the locus of the firm, each in a different way.

The Traditional Scope of Innovation Management and the Need for Profitable Business Models

It is useful to distinguish between product innovations and process innovations. To the public, new innovative products are generally much more visible than process innovations. However, if we look at innovation cycles, process innovations exert a much stronger influence on business change.

As humans, we typically overestimate short-term changes effected by product innovations and at the same time underestimate the medium- and long-term changes arising from process innovations!

The traditional framework of reference for innovation management in firms and organisations has its valid and well-known foundations. These include the formulation of goals and strategies, the management of innovation processes, the creation of an innovation-friendly enterprise culture, and the creation of a supporting information infrastructure.

However, the real test for the innovation capability of organisations consists in overcoming the insecurity about success or failure of the chosen path, in managing the multi-organisational complexity and the dynamics of innovation, as well as in overcoming the unavoidable and necessary conflicts among all the stakeholders, the challenges of working in geographically and organisationally distributed teams, the continuing conflict between the intended developments and existing products and services, the arguments about the image of the company, and the issues of public opinion and compliance. The higher the degree of novelty and the higher the uncertainty and the risks of failure, the higher the possible profits! If organisations cannot welcome conflicts as a welcome side effect of the business and cannot overcome them, they will also not establish a true innovation culture.

The traditional view of innovation processes – divided into phases such as situation analysis, creation of ideas, systematisation, evaluation, selection, implementation, and market introduction – shows important elements but is no longer enough.

Today's markets require a much more holistic view of entire value networks and much more agile rapid research and development. Potential gains through new or improved products and processes are not enough; business models to create real profits must be provided simultaneously and become an integral part of innovation. If necessary, these models can take the form of entire business ecosystems within which innovations can be marketed, developed, and deployed. Apple's iTunes and mobile devices are a good example.

Pertinent questions are the following: How can an organisation change or redefine the rules of an entire industry? How can money be made from the newest tools, from an improved product, from a well-targeted services offering, from a fabulous logistical effort, and at which point, at which price, and without the competition immediately copying such offers, or, worse, leapfrogging them?

Satisfactory responses include flexibility and agility, fine-tuning of the antennae in the markets, and a readiness for radical changes while maintaining motivation and credibility.

How will you earn money with your innovations? Who will you be for whom? The answers change as innovations leapfrog each other, in irrational jumps, across the life cycles of products and services. Business intelligence combined with modelling and simulation tools help to deal with the painful experience of such jumps and help to explore promising scenarios.

Open Innovation

Open innovation (b) is a term originally associated with Henry Chesbrough (2003) of Berkeley University. The basic idea was that since knowledge is widely distributed in the world, companies had better no longer solely rely on their own research but should instead obtain licences and processes (including patents) from other companies. Additionally, proprietary inventions not needed in a firm's business should be proactively offered outside through licensing, joint ventures, and spin-offs.

In contrast, closed innovation refers to processes limited to the company, with little or no use for external knowledge.

With today's communications systems, it seems impossible to prevent an exchange and transmission of information, and the open innovation community actively advocates taking advantage of outside knowledge. The business models of firms then determine which external information to bring in and which to take outside.

The important cultural change is an ability to partner and to deliberately disregard the old NIH, the *not-invented-here* syndrome. This will work if there is management attention and endorsement, and a process for finding, vetting, and leveraging outside sources of information. Greater permeability is needed to become not only a guardian of intellectual property rights but also a broker and seller of such rights to others.

Numerous top companies – as well as their suppliers – are now in open innovation mode, among them many consumer goods and electronics companies. Some of these, such as Procter & Gamble, have established innovation networks for conveying their mission and requirements; others have developed open innovation into part of the way they do business.

Several patterns for the use of open innovation have emerged, each building on the others:

– Some firms agree to use open innovation on principle and encourage their staff to find answers outside the organisation.
– Others have nominated a person to coordinate all open innovation aspects of a company.
– Yet others have nominated a person to actually implement an open innovation strategy.

– Finally, some have defined multiple points of contact for open innovation in all departments, businesses, and/or technical domains.

Typical stages in open innovation are idea formulation, product design, production, and distribution and sales. Idea formulation involves issues of trust within your network. Product design is the sweet spot of open innovation; written specifications and customer requirements can more easily be defined than in other stages and posed to multiple innovation partners. Global production is a significant reality. Some of the most innovative products and services achieve their success at the stage of distribution and sales, with innovative shipping, sales channels, merchandising, and other marketing effects.

Before reaching out to a wider public, vendors and customers are brought into the system. An example is Innovia Technology's innovation need for increased passenger comfort on long-haul flights with the Boeing 787 and the open innovation result of advanced LED lighting which adds to a sense of space and enhanced comfort in the cabin.

The SAP Co-Innovation Lab (COIL) and its industry partners (Cisco, HP, Intel, NetApp) try to find a way to integrate hardware and software innovation and yet be protective of intellectual property. Work is done in a collaborative but safe environment, in a SAP facility in Palo Alto, California. Recently, facilities in Tokyo, Bangalore, and Sao Paulo have been added.

German pharmaceutical firm Merck & Co. (in Darmstadt, Germany) which accounts for about 1% of biomedical research in the world decided as early as 2000 to open up its innovation processes, stating *to tap into the remaining 99%, we must actively reach out to universities, research institutions and companies worldwide to bring the best of technology and potential products into Merck. The cascade of knowledge flowing from biotechnology and the unraveling of the human genome – to name only two recent developments – is far too complex for any one company to handle alone* (www.anrpt2000.com/innovation2.htm).

This author leads several projects in which companies cocreate and co-market products and services as part of *federal product development and marketing* efforts.

Many formal and informal mechanisms have been deployed for pre-qualification for participating in open innovation by third parties, so-called accelerators. These, in turn, have become an industry of their own. They vet large numbers of innovators, handle intellectual property issues upfront, support innovation-against-specification and mission innovations, and generally position themselves as reasonable for any size company. On the downside, they add an additional layer of administration.

A distinction can also be made between using (1) business partners as an open innovation network, (2) using suppliers, and (3) using customers. Each subgroup has its own characteristics, with advantages and disadvantages (Blackwell and Fazzina 2008).

Initial experiences with open innovation and the new alliances indicate that companies with a stated focus on open innovation are more easy to partner with. Also, the logistics for open innovation can be expected to be ill-defined; it is therefore useful to focus on the intent, or mission, and not on the process. Our findings from action research indicate that it helps to signal a willingness to look for disruptive technology since open innovators will readily attempt to reinvent processes. Participation modes in innovation networks differ greatly, and participants must expect diversity rather than uniformity. *Old-school* caution – evident in the outsourcing of R&D to countries such as India and particularly China – dictates that collaboration be modularised; more recent approaches advocate communicating the mission aggressively, while details are to be communicated more slowly.

Important questions remain: What are the performance implications of open innovation? What appropriate metrics are there for measuring and managing open innovation? What failure cases exist that show the limits of open innovation or its boundary conditions? How does open innovation change the role of IP in the firm? What new practices do we need to develop in order to become more successful in open innovation?

Crowdsourcing and Social Media Creation

To many, crowdsourcing (c) is no longer a foreign concept. This model has become very visible in the creation of new knowledge and software over the Internet. Examples are Wikipedia and Linux or the Firefox browser.

Social media provide new avenues to global talent, and many see crowdsourcing, mass sourcing, user-led content, and product creation as the inevitable path towards a super-democratisation of processes and internal decisions in the corporate environment. This assumes that companies will be giving more and more space to outside people's opinions during all stages of technology production. Retail has been particularly successful with such an approach. Amazon, Skype, and Google have used parts of this model with success, albeit not in terms of equality. Starbucks involves customers in decisions, and Lego empowers its fans with a personalised input channel.

Dedicated websites such as InnoCentive have sprung up to tap the mass innovation market.

The author anticipates that communities such as LinkedIn, Futurecom, Xing, Facebook, Twitter, Goggle+, and many others will position themselves as conduits to consumers for the mass creation of products and services. A growing industry has already been established and handbooks written on how to use social media, coupled with lots of advice for the implementation of company-specific social media policies (e.g. Robert Wollan et al. 2011).

Pharmaceutical companies have started to cocreate with patients, with the help of social media. An EU project, PatientPartner, promotes the role of patient organisations in clinical trials.

Thousands of new consulting firms have sprung up in recent months promising to deliver the fruit of user-generated content and products to the many bewildered companies whose business model this very same movement challenges and threatens.

Questions remain: How relevant is crowdsourcing for us? Which models work? How do we need to behave? How do we need to change ourselves as companies and organisations for the most advantageous use of crowdsourcing? How do we maintain the quality of our crowdsourcing beyond initial contact and ideas? Can we use captive crowds interested over the life cycle of our products and services? How do we give feedback? Can we sustain our crowdsourcing and social media efforts?

M2X, Self-Managing Intelligent Environments, and Cyber-Physical Systems

M2X (d) stands for machine-to-machine or machine-to-human or other combinations. Essentially, cyber-physical systems (CPS) are a disruptive technology with a huge potential for entirely new business models (Geissberger and Broy 2012).

Many benefits are expected from such networked intelligent technology, ranging from simple to complex:

– Embedded systems (e.g. in car airbags)
– Networked embedded systems (e.g. the autonomous flight of a drone)
– Cyber-physical systems (e.g. an intelligent networked street junction)
– Internet of things, data, and services (e.g. the Smart City)

Possible uses for cyber-physical systems in the smart city, for example, exist in transport, energy, health, governance, management of buildings, production, and logistics and are connected to buzzwords such as smart mobility, e-mobility, smart grid, micro grid, ambient assisted living, e-health, smart home, smart factory, smart logistics, and many others.

At some stage in the future, sensor-based autonomous systems are expected to deliver tailor-made, individual services or entire support environments to (human) individuals.

The characteristics of cyber-physical networks determine the quality of the technology management associated with their use. The relevant dimensions are:

– The degree of interconnectedness, possibly in real time, and the dependence on the co-operation of subsystems.
– The nature of the man-system interaction. In industrial contexts, this implies complex management, control, and monitoring tasks. In the private sphere, one would expect such technology to adapt itself interactively to the context, needs, and capabilities of users; sensors would interpret situational data and then coordinate delivery of the required services.
– The degree of openness and autonomy in tasks related to communications, coordination, control, and decision-making, with important implications for reliability and trustworthiness vis-à-vis users and associated systems.

Much like nanotech materials allow us to build new materials on an atom-by-atom basis, the promise of sensor-based networked environments is that they would allow us to build entire business models from scratch, based on sensor-based networked environments, and enhance our human capabilities.

Associated technology management challenges are the establishment of networked infrastructures, application architectures and CPS platforms, data capture and interoperability, establishment of knowledge domain models, establishing and maintaining security, ascertaining the participatory interaction of man and machine, the creation of trust in the reliability of such systems, and, above all, putting them into productive practice.

In short, innovation will come with even more complexity and uncertainty, as well as a good deal of political baggage (security, privacy, risk, participation, inclusion). Enormous engineering challenges will require international collaboration and will also lead to a massive domain convergence in order to profit from the new opportunities, that is, to a rearrangement of the competitive landscape.

Living labs will flourish and showcase innovations and in order to gain competitive advantage and market share through swift deployment.

Cloud and Mobile Computing

Cloud computing (e) has arrived with a vengeance and – combined with an increase in the mobility of users and a plethora of mobile devices – signals yet another shift in the business model. Cloud computing, now a major IT (and implicitly, services) movement, is steadily expanding its scope. This scope was initially described in IT terms as:

- Commodity infrastructure as a service (IaaS)
- Enterprise IaaS
- Platform as a service (PaaS)
- Software as a service (SaaS)
- Cloud storage
- Hybrid clouds
- Private clouds

The infrastructure and offerings of the cloud are still being built by start-ups, practitioners, consultants, and many big-name companies.

In the architecture of cloud computing, laptops, servers, desktops, tablets, and phones remain outside the cloud, while content, monitoring, collaboration, communications, finance, object storage, identity, queues, databases, computing, storage, and network are part of the cloud platform infrastructure. The foundation of cloud computing is the broader concepts of converged infrastructure and shared services. The holy grail of the cloud is the delivery of business services, just as it was the case with its precursor, outsourcing.

Cloud computing was made possible by the availability of high-speed networks, low-cost computers and storage, and the widespread practices of hardware virtualisation, service-oriented architecture, and the increasing perception of computing as a utility. In Europe, privacy and data security reservations as well as legal compliance requirements have slowed the growth of general cloud computing, in favour of private or hybrid clouds.

While the providers of cloud services attempt to make it easy for users to onboard, there still exist technology management challenges in cloud engineering. Cloud engineering is the application of engineering disciplines to cloud computing. It brings a systematic approach to the high-level concerns of commercialisation, standardisation, and governance in conceiving, developing, operating, and maintaining cloud computing systems. It is a multidisciplinary method encompassing contributions from diverse areas such as systems, software, web, performance, information, security, platform, risk, and quality engineering.

The technology management buzzwords from the point of view of users are agility (in provisioning), APIs as interfaces, cost (typically, a usage model), device and location independence, virtualisation, multitenancy (centralisation, peak load capacity, efficient utilisation), reliability (especially suitable for continuity and recovery), scalability and elasticity, open standards, open source, performance, security, and easy maintenance.

However, cloud technology will not solve all of a company's problems. One needs to leverage this technology around the right strategy and with the right people. Training should be a huge part of the deployment plan for cloud management tools, and firms will want a policy to constantly monitor their effectiveness.

Persistent questions remain: Is privacy assured? Data integrity? Is my version of the cloud compliant with my industry rules and regulations? What about data leakages and cross-national data transfers? Is cloud computing sustainable, green? Can cloud computing be used for criminal activities? How can companies switch providers or regain control? How reliable is the system? What is its availability? What about data ownership, business continuity, and disaster management?

Governance: Power, Conflicts, and Influence

Governance is absolutely necessary in any collaborative venture, be it explicit or implicit. For the more traditional forms of collaboration, well-known formats have been established which enjoy great reputation, such as those advocated by Prince, the Project Management Institute, and many others.

Rules and procedures have been successfully introduced for *governance in hierarchical industries*, with tier 1, tier 2, and tier 3 suppliers, and good models exist for communities of practice in which people work on a common theme. Governance elements for these particular business models include:

– Business requirements negotiated among stakeholders, often driven by the major partner/OEM/financier
– Agreed and constantly maintained information confidentiality, integrity, availability, reliability, efficiency, effectiveness, and correctness
– Multilateral planning of data, applications, technology, equipment, and personnel
– Controlling in order to coordinate, react, adapt, assure operations, and safeguard against risks

– (endlessly discussed) Resources and their availability
– Arrangements upon dissolution of the network

One level up is *large programme management*, that is, the management of very large or many related projects. Various attempts are being made to capture the specific requirements and formalise adequate techniques to master such large programmes. For example, Said Business School in Oxford has established an institute, prodded and supported by telecommunications monopolist British Telekom. Brandenburg Technical University is currently in negotiations to establish an international centre for large programmes management, with this author as its founding director.

The challenge in large programme management is typically to manage large, dispersed, and culturally diverse and virtual project teams. Dissimilar procedures, practices, and tools often lead to integration issues. Risk perception is complex, and risk management tends to be inadequate and inconsistent, leading to unknown events. The integration of the interdependent components offered by different teams provides great challenges and often leads to failures. Management therefore needs to be adaptive, preferably with a multicultural background and experience and with the will to establish a similarly experienced core leadership team. Above all, in large programmes, one needs to leverage the power of teams and build great, empowered, agile teams. While using edge-of-chaos management when innovating and experimenting, the teams must be instilled with a culture of discipline. It helps to see virtual teams as strategic assets, and – from personal experience in large programmes – it pays to insist on face-to-face meeting for planning and decision-making. Contractor teams must be led but not micromanaged while at the same time using standard procedures and tool as appropriate. Collaboration and open communication must be proclaimed as important virtues, and management must provide the best example.

In the cases of the *crowdsourcing*, *self-managing sensory environments,* and the *cloud/mobility* (c–e) models, governance is mostly untried. The technology management issues remain, that is:

– Process optimisation: How does one coach, facilitate, collaborate, train, and bring multidisciplinarity to bear, combine inputs, and expand the partnerships?
– Enhanced knowledge transfer: How do we do this effectively? How is knowledge disseminated? Rules? Techniques? How about cross-fertilisation?
– Enhanced technology transfer: What are effective ways to do this? To what purpose? Dissemination? Cross-fertilisation?
– Protection of intellectual property: How important will this be? Shall we be exploited? What contexts fit which sort of behaviour?
– Achievement of long-term goals: How can we renew, direct, support, coach, intervene in crises, settle conflicts, and measure productivity and growth quantitatively and qualitatively? Can we sustain our presence in this space?

These questions provide a rich seam to be mined for for research and development.

Basically, power is a latent resource which must be unleashed by other processes. The key unleashing process is influence, which uses interpersonal and social skills to make others voluntarily change their attitudes. *That is* why people are our most important resource.

Enabling Collaboration and Teams with Technology and a Culture of Encouragement

We consider collaboration as an interactive process among two or more people who communicate with each other and work together, towards the achievement of common goals. The term "collaboration technologies" has come into use to denote a whole raft of products and services designed to enhance organisational performance and productivity in industries and markets. These include specifically voice, video conferencing, content sharing, telepresence solutions, social networking, shared workgroup sites, discussion boards, blogs, wikis, IM, and text messaging. We can expect many more.

Collaboration technologies, too, must be selected and deployed aligned with the business model which they are to support.

Culture can be the worst innovation killer. If a company's leadership and culture focus on criticising new thinking and new methods, then innovation is doomed. Risk-encouraging enterprise cultures reward and value innovation, value knowledge, and reward project work (rather than core work); they advocate the sharing of information and are open to informal power. Only with mutual encouragement will we all be able to stand the pace of change.

Summary

Demands for technology management skills will increase dramatically, as business models and technology models continue to evolve and proliferate.

Lifelong learning of technology managers will have to be coupled with character traits which foster innovation, such as a yearning for better thing and things that do not as yet exist, tolerance for uncertainty and ambiguity, a willingness to take risks, a belief in the value of new things in general, a belief in the ability to obtain valued benefits from innovation, participation in richly connected social networks, a willingness to experiment, and an ability and willingness to go the extra mile and invest in various kinds of resources in the new thing – and a head for finance and business plans.

Each of the five tectonic changes (a–e) mentioned above creates its own research questions and technology management challenges. These models – while coexisting simultaneously and legitimately – show a great diversity, on a continuum from decentralisation to centralisation. They also differ greatly in the way they involve their users and define the boundaries of the firm.

Looking forwards, we shall be seeing even more complexity, even more powerful and globally integrated technology platforms offered by third parties, and also an ever greater competitive scramble for successful business models based on advanced forms of collaboration. Successful companies will keep their ears to the ground and listen carefully to their customers.

Courage and determination will be needed in order to exert influence, survive, and flourish.

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Understanding Social Business

Ravi Vatrapu

Introduction

Social media are fundamentally scalable communications technologies that turn Internet-based communications into an interactive dialogue platform (Montalvo 2011). On the "demand side", citizens, users, and consumers are increasingly turning to various types of social media to search for information and to make decisions regarding products, politicians, and public services (Bimber 1998; Haugtvedt et al. 2005; Vollmer and Precourt 2008). On the "supply side", terms such as "Enterprise 2.0" (McAfee 2009), "Government 2.0" (Tapscott et al. 2007), and "social business" are being used to describe the emergence of private enterprises and public institutions that strategically adopt and use social media channels to increase organizational effectiveness, enhance operational efficiencies, empower employees, and create value with and for stakeholders.

The remainder of this chapter is organized as follows. The first section situates the notion of social business in the relevant macro trends in technology, organizations, and society. The next three sections present and discuss three critical aspects of social business: social business engagement, social media analytics, and social media management. This chapter concludes with implications for strategy, marketing, innovation, knowledge management, human development, and public governance.

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Trends in Technology, Society, and Organizations

The increasing societal adoption of information and communication technologies is resulting in two distinct phenomena that have been termed "digital positivism" and "brand panopticon" (Vatrapu et al. 2008).

Digital Positivism (Adapted from Vatrapu et al. 2008)

Civil society actors are increasingly using the Internet to document and share social and physical reality. The documentation and dissemination of events and intersubjective perspectives on objective events were once the sole province of professional occupations such as journalism, marketing, and public administration. Before the advent of the Internet, there was controlled access to the mass media publication avenues of print media, public television and radio, network television, broadcast radio, and cable television. The rapid diffusion of low-cost audio-video recording devices such as mobile phones, camcorders, webcams, digital voice recorders, and computers and the availability of free or affordable Internet hosting and sharing services have empowered civil society actors with the capabilities to record and share their lives as well as their realities. This capability has also been extended to record, comment on personal lives, social interactions, and experiences with goods and services. This emerging new human relationship with external reality is termed "digital positivism". In digital positivism, the objective reality of an event is intersubjectively established through the warrants of digital artefacts that are themselves based on technological grounds. The degree of the objective reality of an event in the intersubjective public discursive realm, under digital positivism, depends therefore on the positive ontological existence of a digital artefact. Implications for businesses are that there has been a radical transformation in the conception and discussion of product categories such as music, movies, and books and the associated practices of product searching, ordering, and buying.

Brand Panopticon (Based on Civic Panopticon in Vatrapu et al. 2008)

Foucault (1977) invoked Bentham's notion of "panopticon" in the penitentiary institutions as a way to discursively constitute the subject and to "discipline and punish" the socially deviant and ethically errant subject with technological means. The emergence of digital positivism with respect to interactions with organizations, products, and services results in a profound shift in how marketing professionals go about their trade. As the cliché goes, "*the brand is no longer what the marketers tell* *the target group but what they tell each other*". For organizations, the potential challenges are not limited to marketing as the whole supply chain can be subjected to monitoring, deliberation, and argumentation by stakeholder groups resulting in "brand panopticon".

Concomitant Convergence

As the e-Media report (Lindqvist et al. 2008) points out, technological convergence and terminal convergence lead to service convergence. The evolution of touch-screen smartphones with high-speed mobile broadband, wireless Internet access, and mobile apps is a good example for the concomitant convergence of technologies, terminals, and services. This is further evidenced by the slogan "there's an app for that" with regard to erstwhile services. Four particular concomitant convergences are relevant for the purposes of this chapter:

- *Design*: local, social, and mobile
- *Media*: owned, paid, and earned
- *Interactions*: my place, your place, and our place
- *Scorecards*: people, planet, and profit

Design: Local, Social, and Mobile

The coming together of social computing, local business discovery, and mobile applications has been hailed as "SoLoMo"[1] (portmanteau of social, local, and mobile). This concomitant convergence refers to the deployment of mobile applications in order to intertwine the online social world of the users with the local physical contexts and services of organizations.

Media: Owned, Paid, and Earned

With respect to the marketing communications from the organization and the customer conversations about the organization, there is a tripartite distinction of the media world: owned media, paid media, and earned media.[2] Owned media refers to the media properties owned and controlled by the organization (e.g. website). Paid media refers to the purchasing of advertisements and promotional materials in media channels (e.g. TV commercials, search engine marketing in the form of Adwords on Google, Facebook advertisements). Earned media refers to the coverage in traditional and new media channels that is not directly paid for.

[1] http://schott.blogs.nytimes.com/2011/02/22/solomo/

[2] http://mashable.com/2011/06/23/paid-earned-owned-media/

Interactions: My Place, Your Place, and Our Place

Just as with media, a tripartite distinction can be made with respect to the customer-organization interactions. From an organizational point of view, my place refers to the customer interactions located on discussion forums owned and controlled by the organization (e.g. customer support forums). Your place refers to the customers' interactions with the organizations' goods and services at their own personal interactional sites (e.g. Facebook wall of a customer). Our place refers to interactional spaces that engender a sense of community and co-ownership between the organizations and its consumers (e.g. a Facebook page of a brand community).

Scorecards: People, Planet, and Profit

With the emergence of Balanced Scorecards (Kaplan and Norton 1992) as strategic management systems, the debate on corporate social responsibility (Friedman 2007; Harrison and Freeman 1999) and the current social media revolution, social responsibility, environmental sustainability, and economic profitability become critical dimensions of measurement and evaluation for both organizations and its stakeholders. As such, the new generation of business scorecards needs to compass metrics and key performance indicators across these three critical organizational dimensions.

The emerging paradigm of "social business" is situated in the socio-technical confluence of these interrelated transformational developments in technology, organizations, and society. New organizational roles such as *community manager*, *social media architect*, *social media analyst*, *social media manager*, *and chief listening officer* have emerged to meet the associated technological developments, organizational transformations, societal changes, and market demands. However, current state of knowledge and practice regarding social media engagement of and social media conversations about organizations is rife with numerous technological problems, scientific questions, operational issues, managerial challenges, and training deficiencies. This chapter seeks to address the current state of affairs with a conceptualization and exposition of social business and its three critical dimensions of social media engagement, analytics, and management. Social business is described and defined in the next section.

Social Business

To restate, the *Internet* resulted in a *vertical integration of organizational channel capacities* such as production, distribution, transaction, and communication and a *horizontal integration of organizational communications* such as advertising, public relations, and promotion (Li and Leckenby 2007). *Social media* channels that emerged from the participatory turn of the Internet facilitated by developments in social computing created new opportunities for interaction and innovation within and across the different stakeholder groups in both the public and the private sectors. The increasing adoption and use of social media channels in organizational settings is resulting in a new kind of organizational paradigm that is termed "social business".

A *social business* is an organization that strategically engages, analyses, and manages social media to structure organizational processes and support organizational functions in order to realize operational efficiencies, generate comparative advantages, and create value for customers, shareholders, and other societal stakeholders.

The next three sections will define and discuss the three critical aspects of social business: social business engagement, social media analytics, and social media management.

Social Media Engagement (smE)

Social media engagement concerns the organization's strategic use of social media channels to interact with its internal and external stakeholders for purposes ranging from knowledge management to marketing, customer support, and product development.

The crucial first step in the social media engagement (smE) of an organization is the creation of a social media strategy that is in alignment with the corporate strategy of the organization. Irrespective of the particular organizational unit that initiated the social media engagement of the organization (typically by marketing or customer support), the social media strategy exercise should survey the entire organization and identify the different organizational stakeholders (Wollan et al. 2011). Social media policies and guidelines for employees should accompany the social media strategy for the organization.

Marketing communications tends to be the primary reason in the initial adoption of social media in organizational contexts (personal communication, Jonas Klit Nielsen, CEO of MindJumpers, Denmark). As such, smE practitioners need to understand key concepts in online marketing such as the *compression of the hierarchy of effects* (i.e. the traditional cascade of cognition, affect, and behaviour can be compressed in space and time with regard to online advertising, e.g. iTunes store of Apple Inc.), *decision heuristics*, *integrated marketing communications*, and *segmentation* (Haugtvedt et al. 2005; Schumann and Thorson 2007). Further, social media marketing requires an understanding of the concept of *exchange* for research and practice in marketing and its applicability to the social media engagement of an organization (Bagozzi 1975; Grönroos 1991; Kotler and Levy 1969).

Social Media Analytics (smA)

Social media analytics (smA) refers to the collection, storage, analysis, and reporting of social data emanating from the social media engagement of and social media conversations about the organization.

The organizational and societal adoption and use of social media is generating large volumes of unstructured *social data* that is popularly termed "big data". As mentioned earlier, current state of knowledge and practice regarding social media engagement of and social media conversations about organizations is rife with numerous technological problems, scientific questions, operational issues, managerial challenges, and training deficiencies. For instance, given the unstructured nature of social data, many organizations are not in a position to extract meaningful and actionable information in a timely fashion. Moreover, there are critical challenges associated with how social data integrates with the existing datasets of an organization (house data) and its relevance to the key performance indicators for the organization (Lovett 2011; Sponder 2011).

Many commercial software vendors (such as Radian6,[3] IBM Cognos Consumer Insight,[4] SAS,[5] PageLever,[6] Skyttle[7]) are proving software solutions to monitor, measure, and manage social data. The key problem is that there is little-to-no empirical research on the efficacy and impact of the different social media metrics employed by the different social media analytics tools and the different social media analytics solutions they provide. Current theory development, empirical research, and technical development projects at CSSL are concerned with addressing the issues with social media analytics.

At the Computational Social Science Laboratory (CSSL), our approach to social data has been to make a distinction between "*social graph analytics*" and "*social text analytics*". *Social graph analytics* concerns the actors. Social graph is "*the network of personal connections through which people communicate and share information online*".[8] Social text refers to the content of the online interactions, conversations, and discourses. Social graph analytics is concerned with the actors involved, the actions taken, and the artefacts created and interacted with (e.g. Robertson et al. 2010). Social text analytics is concerned with the topics discussed, categories mentioned, keywords deployed, pronouns used, and sentiments expressed. We are currently creating a technical architecture and technological infrastructure for the collection, storage, and provisioning of social data for designing and evaluating various metrics, KPIs, and visual analytics solutions.

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[3] www.radian6.com

[4] http://www-01.ibm.com/software/analytics/cognos/analytic-applications/consumer-insight/features-and-benefits.html

[5] http://www.sas.com/software/customer-intelligence/social-media-analytics/

[6] http://pagelever.com/

[7] http://friends.skyttle.com/

[8] http://fluent.razorfish.com/publication/?m=6540&l=1

Social Media Management (smM)

Social media management (smM) focusses on the operational issues, managerial challenges, and comparative advantages with respect to the emerging paradigm of social business.

Social media management (smM) is conceived as a distinct specialization in the research and practice of management to supplement the six traditional types: human resource management, operations/production management, strategic management, marketing management, financial management, and information technology management.

smM is concerned with both operational issues and managerial challenges resulting from the adoption and use of social media channels in an organization both internally and externally. To jump-start the discussion on the concept of social media management and its purported functions, the two issues of comparative advantages and innovation are discussed briefly.

Social Media and Comparative Advantages: The Relational View of the Firm

Social media management is grounded in the relational perspective of the firm's competitive advantages instead of the structural or resource-based views. The structural perspective states that "*supernormal returns are primarily a function of a firm*'*s membership in an industry with favourable structural characteristics* (*e.g.*, *relative bargaining power*, *barriers to entry*, *and so on*)" (Dyer and Singh 1998, p. 660). The resource-based view (RBV) "*argues that differential firm performance is fundamentally due to firm heterogeneity rather than industry structure*" (Dyer and Singh 1998, p. 660). In contrast to the industry structure view and the resource-based view of the firm, the relational view of the firm argues that "idiosyncratic interfirm linkages may be a source of relational rents and competitive advantage" (Dyer and Singh 1998, p. 661).

Social Media and Innovation: Absorptive Capacity

Building on the relational view of the firm, social media can enhance the *absorptive capacity* (Cohen and Levinthal 1990) of an organization by connecting and exposing the different stakeholders to multiple sources of information and diverse knowledge networks. Social media can be instrumental for the management of innovation (Burns and Stalker 2009) and open innovation (Gassmann et al. 2010). In particular, social media can be leveraged to harness the "wisdom of the consumer crowds" for collective innovation (Kozinets et al. 2008).

Discussion

"*An organization is both an articulated purpose and an established mechanism for achieving it*" (Miles et al. 1978, p. 547). Adapting to environmental change and uncertainty requires that organizations maintain an effective alignment to the environment while maintaining internal dependencies (Miles et al. 1978). The emergence of social business and its three critical aspects of social media engagement, analytics, and management can be conceptualized within the *adaptive cycle* organizational framework of Miles and colleagues (1978). In this regard, social media engagement, analytics, and management need to be considered within the three broad organizational problems (the *entrepreneurial problem*, the *engineering problem*, and the *administrative problem*) leading to the classic strategic typology of *defenders*, *prospectors*, *analysers*, *and reactors*.

With regard to the evolution of social media engagement, analytics, and management of an organization, Spondor (2011) proposes four levels of social business maturity:

- *Level 1*: monitoring
- *Level 2*: online research
- *Level 3*: social targeting and data management
- *Level 4*: social business collaborations

The key to embracing social media and increasing the level of social business maturity is the realization that unlike most other enterprise information technology (such as ERP, CRM, Office Productivity Software), social media is not yet commoditized. As such, contra Carr (2004), social media as an information technology does matter as it is not yet an infrastructural technology. Strategic and innovative practices of social media engagement, analytics, and management can create stakeholder value. In the last and final section to follow, a proposal for a large-scale collaborative research project on socially connected organizations is presented along with the articulation of a set of research questions, anticipated scientific advancements, and societal benefits.

Socially Connected Organizations: A Research Proposal

The current state of knowledge and practice is characterized by a lack of large-scale interdisciplinary scientific study of the diverse but interrelated aspects of social media adoption and use in organizational settings. There has not been a large-scale integrative initiative to bring together the researchers from different academic disciplines and practitioners from public- and private-sector organizations to empirically address the scientific questions, technological problems, organizational challenges, and training deficiencies associated with the current state of the adoption and use of social media by organizations and their stakeholders in the society. Such a large-scale integrative research effort that combines academic rigour with instrumental relevance is essential for engendering and sustaining strategic growth of the global society. A set of scientific research questions are presented below.

Socially Connected Organizations: Research Questions

From an academic perspective, some of the research questions with respect to the social media engagement, analytics, and management of an organization are:

- To what extent and for what purposes do organizations engage in social media channels? And what, if any, are the associated social media engagement, analytics, and management practices and requirements at the organizational level?
- How to design, analyse, evaluate, and optimize technical architecture and technological infrastructure for the collection, storage, and provision of social data resulting from the social media engagement of and conversations about public- and private-sector organizations?
- What are the explanatory mechanisms for the social interactional patterns, dynamics, and communities detected by social graph analytics (Suthers et al. 2010)?
- How to extract feature vectors from the integration of social data with house data by research and development of computational linguistics techniques and tools towards text analytics of social data?
- What is the distribution of ecological, social, behavioural, cognitive, and affective information with respect to social media interaction of users, customers, and citizens?
- How is information structured in a given social media interactional phenomenon of analytical interest?
- How is information perceived, made sense of, and acted upon in social media settings (Vatrapu 2010)?
- To what extent can social media engagement, analytics, and management methods and tools inform managerial decision-making in Danish organizations?
- To what extent can accountability and brand reputation monitoring and management methods and tools create competitive advantages and operational efficiencies in Danish organizations?
- How to create research-based educational training and certification programmes towards competence development of the Danish workforce to significantly address the capacity-building problem of Danish organizations with respect to the emerging organizational roles such as community manager, social media curator/strategist/architect/analyst/manager?

Socially Connected Organizations: Scientific Objectives

- Systematically survey, document, and analyse the perception about and practices with social media channels in diverse organizational settings, public vs. private

sector, and across diverse set of contexts, cultures, countries, languages, religions, and markets.
- Design a technical architecture and develop a technology infrastructure that provides methods, tools, and solutions for social media engagement, analytics, and management by involving researchers from computer science, systems engineering, Internet science, organizational psychology, computational linguistics, cognitive sciences, human-computer interaction, and technology management.
- Empirically investigate the operational issues and managerial challenges in the adoption, use, and impact of social media and social software in organizations and build empirically informed, verified, and validated theories, models, and frameworks for social media engagement, social media analytics, and social media management.
- Identify and strengthen the knowledge base of emerging scientific fields such as visual analytics, predictive analytics, social media analytics, and social media management.

Socially Connected Organizations: Organizational and Societal Objectives

- Deploy a state-of-the-art technical infrastructure and technological solutions into Danish organizations to address technological problems, operational issues, and managerial challenges with respect to social media and social data.
- Develop a framework to empirically investigate the correlation between social media information and key performance indicators for Danish organizations in public and private sectors.
- Develop and evaluate a social media management framework that empowers practitioners to create empirically informed social media management strategies, policies, and practices.
- Design, deliver, and evaluate research-based education programmes to jump-start the certification of and training for the first generation of social media curators, analysts, and managers in university and organizational settings.
- Empower and promote the active engagement of citizens and customers in social media by ensuring that their voice is heard by public institutions and private enterprises.

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Technologies for Sustainable Development: Korean Experience

Paul Jeong, Mysore V. Ravikumar, and Pradip Paul

Introduction

The World Commission on Environment and Development (WCED)'s report in 1987 is viewed as a major political turning point for evolution of the concept of sustainable development (Mebratu 1998). Since then, the influence of the concept has increased extensively, and it features more and more as a core element in policy documents of governments and international agencies (Mebratu 1998).

The concept of sustainability and sustainable development may be understood intuitively, but it remains difficult to express in concrete, operational terms (Briassoulis 2001). However, many agree that sustainable development is about achieving environmental, economic, and social welfare for present as well as future generations (Azapagic and Perdan 2000). From governmental perspective, this can be at national and global levels (UNCSD 2001). From an organizational perspective, this can be at project (Labuschagne et al. 2005) and technology (Brent et al. 2005, 2006, 2007) levels. Sustainable development has subsequently been conceptualized as a state of dynamic equilibrium between societal demand for a preferred development path and the supply of environmental and economic goods and services needed to meet this demand (Briassoulis 2001).

Consensus on the general objectives and basic principles of sustainable development may be obtained in theory. But consensus on the details of how to achieve sustainable development or maintain sustainability is difficult to obtain in practice. This difficulty can be attributed to the variety of perceptions on specific sociocultural and political contexts that change over time (Briassoulis 2001; Brent et al. 2005).

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Sustainable Development and Globalization

Globalization and sustainable development is at the top of today's international agenda, covering a wide range of issues, such as, inter alia, trade, development, environment, resources management, development cooperation, and international governance. The basic understanding of "sustainable development" derives from the 1987 UN World Commission on Environment and Development report, entitled "Our Common Future," as "a development that meets the needs of the present, without compromising the ability of future generations to meet their needs." The report also established that this requirement applies not only to environmental policies but also to economic and social policies as well (Lucas 2004).

Sustainable development is a multidisciplinary process that involves all issues, such as science, innovation, technology, R&D, information technology, e-commerce, economic development, health, foreign direct investment, multinational companies, international debt, and related issues (Ahmed and Stein 2004; Stein 2002).

Sustainable development is based on three pillars: the environment, the economy, and the society. The framework domain for sustainable development should take into account a set of parameters which determine the feasibility of the model for direct beneficiaries, non-beneficiaries, national values, the environment, and the stability of the system. Broadly, sustainability can be defined with the constituents such as:

(a) Economic sustainability
(b) Technological sustainability
(c) Social sustainability
(d) Environmental sustainability
(e) Value sustainability (Abdul Kalam and Singh 2011)

On the other hand, "globalization" refers to the growing integration of the global economy, which is being brought about by incessant flows of goods and services, capital, technology, and information across national borders. In its wider sense, globalization is not only about economic processes; it also covers the increasing cross-border contacts in other spheres, including the exchange of ideas, knowledge, and cultural manifestations. Globalization is, first and foremost, a continuation of the historical process of internationalization, which has increased the economic, social, environmental, and political interdependence of countries (Lucas 2004).

An outcome of globalization is that the international cooperation in science and technology from small cross-border research projects to global-scale coordination must be considered as a key tool for enhancing sustainable technological development in key areas, such as water, energy, health, and education. Thus, there is both a need and a scope for regional and global cooperation in sustainable development. Mechanisms must be put in place to facilitate such international exchange of domestic and global experiences in sustainable development.

Sustainable Development: Dimensions and Areas

There is an inherent linkage (Kates Robert et al. 2005) between “what is to be sustained” and “what is to be developed.” While “what is to be sustained” deals with:

(a) Nature (earth, biodiversity, and ecosystems)
(b) Life support (ecosystem, services, resources, environment)
(c) Community (cultures, groups, and places)

“What is to be developed” relates to:

(a) People (child survival, life expectancy, education, equity, equal opportunity)
(b) Economy (wealth, productive sectors, consumption)
(c) Society (institutions, social capital, states, regions)

Thus, the dimensions for sustainable development are primarily based on three pillars, each of them covering certain areas. They are as follows.

Dimension	Areas
Environment	Climate, water, biodiversity, natural resources, etc.
Economy	Jobs, wealth creation, investments, energies, etc.
Social aspect	Education, health, standard of living, etc.

Energy, water, education, and environment are essential to every aspect of life for social equity, ecosystem integrity, and economic sustainability. It affects all aspects of development—social, economic, and environmental—including livelihoods, agricultural productivity, and health.

To develop technologies for some of the above areas under the three dimensions, right type of innovation ecosystem should be established.

Innovation Ecosystem for Technology Development

An innovation ecosystem consists of economic agents and economic relations, as well as the noneconomic parts such as technology, institutions, sociological interactions, and the culture. Deborah Jackson (Debora Jackson 2011) describes a model of innovation ecosystem based on two distinct, but largely separated, economies: the research economy, which is driven by fundamental research, and the commercial economy, which is driven by the marketplace (Fig. 1).

This model links the innovation spectrum to the two economies in the virtuous cycle, thereby illustrating the projection, along the different development stages, of the available resources within an ecosystem for discovery, technology development, and commercialization. An important feature of a sustainable innovation ecosystem is that the resources available to the research economy are coupled to the resources generated by the commercial economy, usually as some fraction of the profits in the

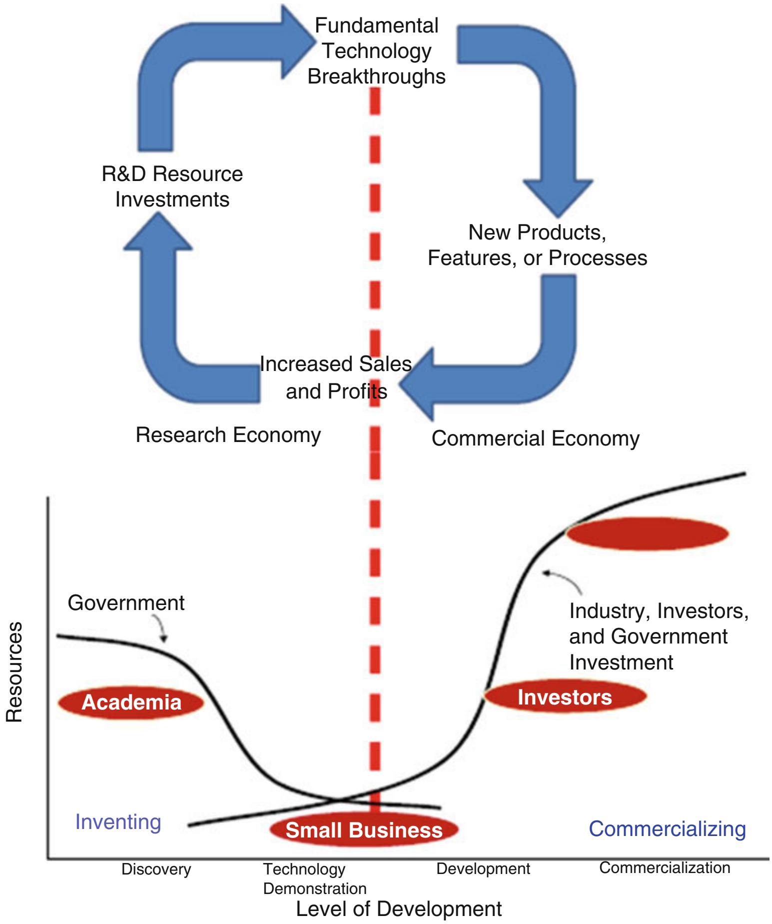

Fig. 1 Ecosystem for discovery, technology development, and commercialization (Adapted from Deborah Jackson 2011)

commercial economy. An innovation ecosystem is healthy and sustainable when the two economies (research and commercial) exist in balanced equilibrium. The challenge to creating growth in an innovation ecosystem is to figure out how to turn the breakthroughs of basic and fundamental research efforts into products that lead to profits. Achieving this goal is complicated by the fact that the two economies operate on different reward systems, thereby making it challenging to link discoveries derived from fundamental research with innovative products that can translate into profits in the marketplace.

Henry Etzkowitz (Henry Etzkowitz 2007; Henry Etzkowitz et al. 2007) has extensively worked on innovation ecosystem based on triple-helix model of innovation and university–industry–government interaction. The triple-helix model is composed of three institutional spheres, viz., university, industry, and government interacting closely while each maintaining its independent identity. In this model, universities, industry, and government assume some of the capabilities of the other, as each maintains its role and distinct identity. The triple-helix model attempts to capture this transformation of roles and relationships among these spheres. There is a shift from typical bilateral interactions (university–government, university–industry, and government–industry) to trilateral interactions among these spheres through increased role taking. Triple helix is an interactive model and consists of overlapping, yet relatively independent, institutional spheres. For example, academia plays a role as a source of firm-formation and regional development in addition to its traditional role as a provider of trained persons and basic knowledge. Government helps to support the new developments through changes in the regulatory environment, tax incentives, and provision of public venture capital. Industry takes the role of the university in developing, training, and research, often at the same high level as universities. Many countries and regions are presently trying to attain some form of triple helix, with university spin-off firms, trilateral initiatives for knowledge-based economic development, and strategic alliances among firms (large and small, operating in different areas and with different levels of technology), government laboratories, and academic research groups.

Korean Technologies for Sustainable Development Areas

Indo–Korea Science and Technology (IKST) Center, a section 25 company established by KIST, provides a platform to showcase some of the successful relevant technologies that are outcome of systematic scientific research done by research institutes in Korea. These technologies have high potential to address some of the developmental issues in the Indian rural context, and these can be applied through appropriate localization process and sustained through community involvement.

Water Purifier Technology

Clean drinking water is a global problem. Globally more than one billion people lack access to safe drinking water, and India has significant share of this deprived population. India faces an enormous challenge in providing its citizens with clean potable water free from pathogenic bacteria, viruses, and cysts which cause diseases such as diarrhea, cholera, typhoid, and amoebiasis. Moreover, due to overexploitation of ground water, the levels of mineral contaminants such as arsenic and fluoride in water drawn from wells have increased dramatically. In rural India, about 75% of the population does not have access to safe drinking water. Hence, clean water for all is a very important societal mission where the scientific community and the industry have to find synergies (Amrit Pal Singh 2010; Abdul Kalam and Singh 2011).

The solutions for clean water are assessed on the following parameters (Abdul Kalam 2011);

- Core technology used and its efficacy in removing the organic, inorganic, and microbes present
- Its cost effectiveness, both in terms of fixed and operational costs
- Ease of use, mobility, and adaptability
- Capacity of water cleaning and maintenance requirements
- Environmental impact
- Its dependence of the other aspects like availability of power and running source of water and the potential solutions

Water purifier technology that has been developed by Korea Institute of Science and Technology (KIST) is basically a low-cost water purification system which ensures all the above-mentioned assessment parameters are addressed effectively. The purification system houses five filters in a compact casing and provides five-step filtration process. This technology completely kills and removes microorganisms, removes solid materials such as iron oxide and sand, absorbs soluble chemicals, and also improves the taste of water. It has very low maintenance cost. This technology could be a very good solution to address bottom of pyramid market.

Sewage and Wastewater Treatment Technology

Conventionally, sewage is collected through a vast network of sewerage systems and transported to a centralized treatment plant, which is resource intensive. Instead of transporting it long distance for centralized treatment, the Central Pollution Control Board is promoting decentralized treatment at the local level using technology based on natural processes. After proper treatment, sewage can be used in pisciculture, irrigation, forestry, and horticulture (Kamyotra and Bhardwaj 2011).

Water Environment Center at KIST has developed wastewater treatment and recycling system technology for treatment of various types of sewage and industrial wastewater using microorganisms. Biological wastewater treatment involves the use of microorganisms (bacteria) to naturally degrade organic waste resulting in biochemical oxygen demand (BOD) and chemical oxygen demand (COD) reduction and wastewater odor control. Wastewater should be treated on site, at local places (decentralized), for example, in restaurants or households, rather than at many wastewater treatment plants. It is an environmentally friendly, relatively simple, and cost-effective alternative to chemical cleanup option. This is an advanced treatment technology. It is composed of an anaerobic tank, an aeration tank, a contact aeration tank and a sediment tank. It removes organic matters by maintaining microorganism concentration in the aeration tank and activating microorganisms in the microorganism controlling tank continuously. It also reduces the bad smell. The treated water can be directly reused (agricultural water, wastewater reclamation, and reuse system), and the dehydrated sludge can be used as compost.

ICT and Robotics in Rural Education

The emergence and convergence of various Information and Communication Technologies (ICT) such as computers, Internet, and multimedia provide unique opportunities for promoting primary and secondary education, on a mass scale, in developing nations like India. There is a general consensus among practitioners and academics that in diverse socioeconomic and cultural contexts ICTs can be successfully employed to reach out to a greater number of students and help in promoting learning and knowledge.

Due to the rapid developments of new technologies, educational researchers can now apply various ICT tools in practical scenarios to enhance learning experiences and performances of learners such as multimedia and robot. Backed by its strong IT environment and advances in robot technology, Korea has developed the world's first e-learning robot. This has demonstrated the potential for robots to be used as a new educational media. Robot technology is expected to become more interactive and user-friendly than computers in the near future. Also, robots can exhibit various forms of communication such as gestures, motions, and facial expressions (Han et al. 2008).

In February 2010, Ministry of Education in South Korea announced that they will equip robots for all 8,400 domestic kindergartens to facilitate instruction by 2013. Educational researchers have shown that the robot as an instructional assistant or as a learning companion can enhance learners' learning motivation and learning performance. Furthermore, using robot as an instructional assistant or a learning companion can also enable instructors to provide learning content which facilitates learners to interact with real objects through navigating digital learning content. For example, while learners are learning physics, the robot can utilize its capabilities, including rotation, mobility, and acceleration, to explain the Newton's laws of motion (Chun-Wang et al. 2011).

KIST has been focusing on the development of intelligent robots and fundamental technologies for robots during last two decades. They have been working on technologies to provide human-friendly services for human beings by combining intelligence technologies and biomimetic sensing-and-control technologies with traditional robot technologies, for example, robots for English teaching, elder care, teaching science, education for disabled/autistic children, edutainment, information services, and home service.

Plasma-Enhanced Integrated Gasification Combined Cycle (PE-IGCC) Technology

The technology under discussion is "Plasma-Enhanced Integrated Gasification Combined Cycle (PE-IGCC)—Electricity Generation Power Plant" using Indian run-of-mine coals having high ash content. This technology can be utilized for small-scale distributed power generation plants in the range of 500–2,000 KW providing electricity in remote villages where grid power is not feasible or not cost-effective. This technology provides a good alternative solution to other types of Decentralized Distributed Generation (DDG) systems based on biomass, solar PV, etc.

Basically, an IGCC-based power plant using coal is a technology that turns coal into gas—called syngas. It then removes impurities from the gas before it is combusted. The electricity is generated using a combined cycle, consisting of three stages:

1. A gas turbine generator that burns the syngas.
2. Heat from the gasification and the exhaust heat from the gas turbine are used to create steam.
3. Then the steam is used to power a steam turbine generator.

Though the IGCC technology is less polluting than conventional coal-fired power plants, it generally requires coal with low ash content of up to 10 %. Although India has a very large reserve of both coking and noncoking coal, the quality of Indian coal is poor due to very high ash content. Typically Indian run-of-mine coals have high ash content (ranging from 40 to 50%), high moisture content (4–20%), low sulfur content (0.2–0.7%), and low calorific values (between 2,500 and 5,000 kcal/kg). Hence, PE-IGCC technology (currently under development) which can make use of low-grade Indian coal could be an excellent alternative to the other existing technologies such as solar, wind, and biomass for rural electrification in India. Typically, existing IGCC technology utilizes high-quality coal (>7,000 Kcal) and high moisture (4–12%) and low lime content (<12%) with high-energy capacity. However, it is possible to use the low-quality coal with 45% lime material for PE-IGCC technology. This technology under discussion is basically a pure steam–plasma torch generated by microwave energy and uses it for gasification of low-grade coal in a compact and lightweight operating system. The high temperature of the steam torch when used for fast gasification reactions of low-grade coal ensures a compact reaction system.

With the largest rural population in the world, India is facing a huge electrification challenge. Today, 64.5% of India is electrified, with an electrification rate of 93.1% in urban settings but only 52.5% in rural areas. This technology once developed will be highly suited for rural India.

Solar Lighting System

The technology under discussion is a high-powered LED-based solar lighting system which could be used for highways, villages, etc. The uniqueness of this system is:

- High powered—60 W
- Communication interface for remote operation
- Tracking of sunlight for maximum efficiency

This technology could be localized for Indian condition considering the cost and wattage specification for various solar PV applications.

From the point of view of rural and remote area electrification, the scope for renewable energy is immense. India has significant potential for generation of power from renewable energy sources such as wind, small hydro, biomass, and solar energy. Special emphasis has, therefore, been given to the generation of grid quality power from renewable sources of energy.

According to National Solar Mission target, off-grid solar PV products/systems would contribute 2,000 MW by the end of 2022. The most of which is to come from solar lighting systems—solar lantern, home light, and solar street light for both rural and urban. National Solar Mission also plans to deploy 20 million solar lighting systems for rural areas by 2022 (National Solar Mission, MNRE).

Education–Enterprise Framework for Emerging Economics

Implementation and management of these technologies require a right framework that shall take in to account requirements of all the stakeholders, resources availability, operational environment, and communication requirements.

The education–enterprise (E–E) model (Biswas et al. 2010; Saurabh 2009; Saurabh et al. 2011) is a special adaptation for BASIC (Brazil, South Africa, India, and China) and emerging economies of the conventional triple-helix model for providing the collaborative framework among academia, government, and the private enterprise focused toward creating social entrepreneurship driven enterprises. E–E model is a diversion from the triple-helix model and hinges more on the mutual interaction of the E–E model with government as a partner. As per E–E model, the needs of the society have been identified under four basic pillars of the society under the education, environment, energy, and health (EEEH) with all of them having equal roles to play in the societal development. Most of the basic needs could be satisfied if entrepreneurs could cater to the needs under the EEEH (education, energy, environment, and health) domain (Fig. 2).

In this framework, the education and enterprise overlap to spin-off social enterprises to improve the social conditions, especially in the emerging/BASIC nations. The government is very much part of the collaboration, but in a noninterfering manner which means that it allows for all necessary infrastructures, monetary, and moral support without interfering in its working. Thus, the model caters to the policy of decentralized power in the hands of the academia (which hosts the program and provides manpower and administrative support) and the industry (which provides the expertise to engage the project). The government role is restricted to monitoring the funding and its utilization. The academia which provides the base for sustenance through knowledge creation under the EEEH framework creates entrepreneurs by using the faculties to train students to become entrepreneurs and innovators. The industry which benefits by getting consultancy and IP generation through innovations coming out of the academia allows the statist BASIC country

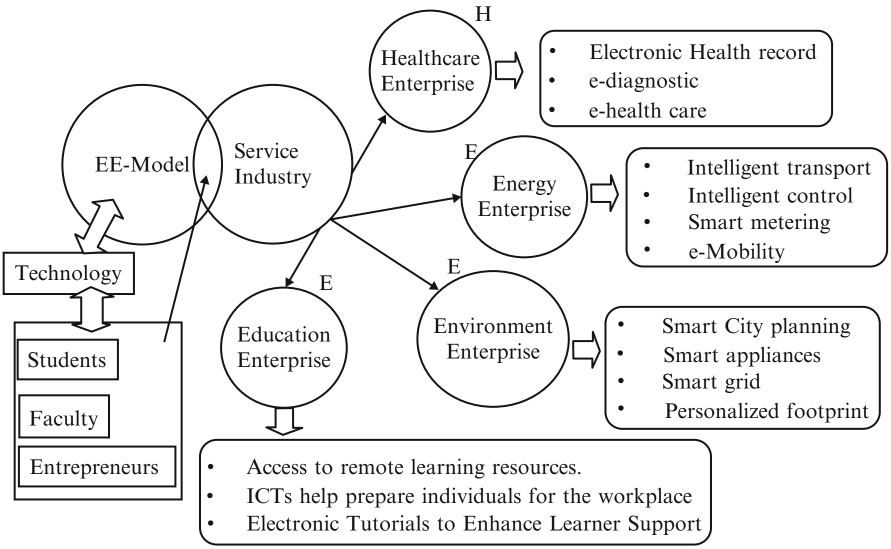

Fig. 2 The co-entrepreneurship model emerging from E–E model (Biswas et al. 2010; Saurabh 2009)

governments to bring in the resources allowing the university campus to be in total free market mode, interacting with private enterprise with a judicious mix of enterprising students and motivated local entrepreneurs. While this will allow invigoration of existing business model involving local people for intense local problems, it will also lead to creation of whole new industry in cluster around the campus. Enterprises in the domain of energy, environment, education, and health help find sustainable solutions to local problems based within the EEEH. Such enterprises will bring in rapid business formation leading to adequate social profit motives in addition to meeting the monetary objectives.

Korean Experience in Technology Development and Management

A spiral process model of technological innovation in developing countries is reviewed by Ali and Park (2011). This can as well apply to developed countries. Any technological innovation cycle passes through four stages: (1) technological innovation (TI), (2) transfer of technology (imitation), (3) adaptive technological innovation (improvement), and finally (4) indigenous technological innovation (local innovation). The development of technological innovation is a cyclic process.

Science, technology, and innovation have been cited as one of the key factors behind the economic success of South Korea. By making continuous and massive investments in research and development and in innovation, Korea has succeeded in building a unique innovation system that supports sustainable growth of the Korean economy. The development of innovation and R&D system of South Korea can be classified under three main processes: imitation process (1960s and 1970s), transformation process (1980s), and innovation process (1990s onward) (Arslanhan and Kurtsal 2010; Sung Chul Chung 2011).

During the innovation process phase, Korean government, along with the Asian crisis that became visible particularly by the second half of 1990s, felt the urge to shift technology policies from large industrial firms prioritized until then to relatively more flexible, dynamic, and innovative SMEs, small-scale R&D centers, and technology-based small firms. Korea's technological competitiveness in semiconductors, displays, cellular phones, computers, telecommunications equipment, and so on is partly the result of the government–industry collaborative R&D.

In recent years and getting halfway through the innovation process, policies targeting to increase basic research have gained ground with the aim to establish an integrated innovation system and secure sustainable economic growth. Recently, with its commitment to the innovation policy, sustainable development, and knowledge-based economy, Korea initiated the creation of the *International Science and Business Belt* (ISBB) to bolster its capacities in the basic and fundamental science areas through the establishment of the Basic Science Institute. One of the objectives of this belt is to lay the business foundation for the sustainable and urban growth. The aim is to foster a business environment to attract global enterprises focusing on R&D in nanotechnology, biotechnology, information technology, and green technology, so that their research can be linked to the basic science research and create a synergy effect facilitating convergence between scenic and businesses (Twa Netwark 2011).

Conclusions

Sustainable development is of utmost concern to the global society today. Though it has often focused on environmental concerns, sustainable development has three dimensions: economic, environmental, and social. The sustainable development requires fundamental changes in the way of growth and development process happening in the world. Industries should develop their business model not only based on economic performance but also taking account of the environment and social impacts. Governments should adopt legislation and regulation on economic activities and environmental issues to enhance sustainability consideration and social awareness. Innovation is an essential driver for sustainable development. There is need for an innovation ecosystem and framework comprising all public and private sector stakeholders interacting closely with surrounding environment rather than a linear model of innovation (basic research) and thereafter technology development (applied research) which gets embedded in useful products and services. The increased interaction among university, industry, and government as relatively equal partners is the core of economic and social development. The linkage between university/research institutes and industry plays an important role for making the ecosystem sustainable and making the society more innovative.

Universities and research institutions in Korea and India have already developed certain technologies in the core areas like energy, drinking water, clean environment, health, and education. However, establishing suitable linkage mechanism between universities/research institutions and industries/investors through appropriate policy interventions and programs will play a key role in realizing the goals of sustainable development.

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Multiagent Coordination Enabling Autonomous Logistics

Arne Schuldt and Otthein Herzog

Logistics Requirements

Supply network management becomes increasingly complex, dynamic, and distributed, e.g., due to the globalisation and the freight structure effect. Due to these challenges, conventional centralised process control turns out to be feasible only for particular applications (Bretzke 2008). The high number of logistics objects as well as their manifold parameters induce a high computational effort of process control. In addition, the dynamics of logistics processes can render optimal plans outdated already in the moment their generation is finished. Furthermore, the spatial distribution of logistics processes often prevents information from being available centrally on time. Central control that tries to generate optimal plans for a complete logistics system is thus frequently not feasible.

The paradigm of autonomous logistics (Hülsmann and Windt 2007) aims at automating process control by delegating decision-making to the participating logistics objects. Based on objectives imposed by their owners, these autonomous logistics entities can themselves plan and schedule their way through logistics networks.

Each entity incorporates only its own parameters as well as those of cooperating entities. Therefore, the computational complexity can be reduced significantly, and dynamics can be dealt with locally. This vision requires not only granting the autonomy but also delegating the ability to make decisions to the logistics objects.

New identification, localisation, sensor, communication, and data processing technologies enable logistics objects, such as shipping containers, to make decisions on their own. This work solves the implementation of decision-making by local data processing as well as the coordination of the individual autonomous logistics entities, therewith enabling the application to perform real-world process control.

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Multiagent-Based Approach

Multiagent systems derived from Distributed Artificial Intelligence have been identified as an appropriate method to implement autonomous control in logistics. Characteristics of intelligent agents are that they are autonomous, that they act both reactively and proactively, and that they are able to communicate and to cooperate with each other (Wooldridge 1999). These properties directly reflect the requirements for autonomous logistics entities. Both logistics service providers and consumers can be modelled with intelligent agents.

Despite their autonomy, however, single logistics objects can hardly satisfy their objectives in isolation. The identified reasons that advocate cooperation among them are twofold. On the one hand, joint actions of objects with similar goals significantly reduce the interaction effort, thereby preventing that the reduction in computational complexity is outweighed. On the other hand, autonomous logistics entities can only jointly meet minimum utilisation requirements of logistics service providers. Hence, cooperation among logistics objects is an important prerequisite for autonomous control in logistics.

A well-known concept in Distributed Artificial Intelligence is the model for cooperation by Wooldridge and Jennings (1999). It formally specifies the steps required for agent cooperation, starting from the identification of a potential for cooperation, over team and plan formation, to joint team action. This concept, however, is rather general and thus abstract which means that particular interaction schemes are underspecified. Based on these general steps, Schuldt (2011) develops specific interaction schemes are required for autonomous logistics.

Three different interaction protocols for team formation of autonomous logistics entities are proposed by Schuldt (2011). The protocols are based on a directory, a broker, and multicast messaging, respectively. Their most distinguishing properties are the degree of decentralisation as well as the interaction effort to be spent for team formation. The interaction effort increases with the degree of decentralisation. Based on this finding, the potential as well as limitations for autonomous logistics are derived analytically. Regarding the team formation mechanisms, this analysis allows for choosing the least complex interaction schemes for a specific application in logistics.

Team formation is the foundation for jointly coordinating the primary logistics functions: transport, handling, storage, and picking. Furthermore, interaction schemes for plan formation and team action are developed. This is accomplished in three steps. Firstly, the allocation of logistics services by individual autonomous logistics entities is operationalised. Secondly, this approach is extended to the joint allocation of logistics resources by teams of autonomous logistics entities. Finally, also the intra-agent coordination of multiple logistics functions is solved. This allows for coordinating multiple primary logistics functions to satisfy complex logistics objectives. Therewith, Schuldt (2011) provides a complete implementation of the general model for cooperation in real-world applications of autonomous control in logistics.

Application and Evaluation

The approach is validated in the context of real-world scheduling processes. As a basis, a comprehensive case study of the procurement logistics processes of a major European retailer of consumer products has been conducted. The company has more than 1,200 own shops and over 56,000 outlets in total. They have particularly high logistics demands because they offer their customers a weekly changing range of products with significant differences in value, weight, and physical dimensions. The case study describes the respective processes and identifies the most important participants.

The transition from previously manually controlled processes to autonomous control has been implemented and validated with multiagent-based simulation. Multiagent-based simulation has a high modelling accuracy because of its one-to-one mapping between the real-world objects and their simulation counterparts. Moreover, the behaviour of autonomous logistics entities in simulation directly corresponds to their behaviour in real-world operations. The simulation is based on real process and dispatch data provided by the company. The behaviour of over 11,500 shipping containers that arrive over the time span of 1 year is examined. The results show that automated process control for standard cases with autonomous logistics is applicable to satisfy even the challenging logistics demands of the project partner.

Autonomous logistics entities are capable of allocating logistics resources efficiently and reliably, thereby considering all parameters defined by the company. The validation reveals that autonomous logistics even exceeds the efficiency of the manual approach. In the examined application, the use of the implemented autonomous control showed potential savings of 2.6 million pallet-days in the warehouses of the project partner per year by better utilising free times at the container terminals. Moreover, the automation allows human dispatchers to concentrate only on the exceptional cases that are not covered by the multiagent system and, thus, provide better dispatching results in these cases than before when they had to handle them under extreme time pressure.

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Managing Technologies for Defense

Prahlada

Introduction

There are two distinctly different subjects – managing defense technologies and managing technologies for defense.

Well, there are people who claim that there are exclusive defense technologies like electronic warfare, missile guidance, and fire-control radars. And they therefore talk about managing creation of these types of technologies.

However, there are hardcore technologists who claim that there is nothing called "defense technology" and that there are technologies which can be harnessed for defense applications also. In such a case, one should not look at just technologies, but how to manage them to get desired products and results.

Let the debate continue. We, at this stage, are interested in addressing the issue of how to manage technologies within the context of defense application. The Ministry of Defence spends about Rs. 100,000 crores every year, and a large percentage of this allocation goes for technologies and technology products whether within India or outside. Technology is there everywhere, not only in weapons and systems but also in vehicles, uniforms, food, communication, training, logistics, housing, and entertainment of defense forces. It is essential that the country develops appropriate technologies, manages them, gets them into products and solutions, exploits them to their full potential, and disposes them safely.

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Technology Watch

Having defined "technology," one needs to also know how the technology can be generated or developed or acquired. There are a number of activities connected with technology, and all are to be managed either serially or simultaneously as part of technology management. Let us list them:

1. Technology acquisition by in-house development or joint development through partner or through transfer from an established source
2. Productization: configuring a salable product incorporating this new technology
3. Productionization: carrying out essential engineering functions so that product can be produced cost effectively
4. Production: volume production of such a product
5. Customization: fine-tuning the product for a particular market or customer
6. Adaptation: modifying the technology for a slightly different product
7. Upgradation: improving the technology for higher performance of same product
8. Exploitation: complete harnessing of a technology in all its forms and nuances
9. Technology integration: integration of more than one technology in one product
10. Technology control: exercising rights and controls such that technology will not get proliferated without owner's approval

India's Unique Ecosystem

When we are talking of defense technology management, it is interesting and essential to note that India has a unique ecosystem as far as defense is considered and that this calls for a special understanding and innovative solution to handle this complex "animal" called "technology" and manage it well.

We have the Ministry of Defence which does the centralized defining, monitoring, and administering of other organs of the ministry, viz., DRDO, ordinance factories, defense production, DPSUs including shipyards, coast guard, the three services, education and training establishments, and private industry contributing for defense.

Independent and Powerful Players

Each of these organs is fairly autonomous and empowered adequately which makes managing them in an integrated way specially in the context of defense technology a big challenge.

The DPSUs and shipyards are commercial organizations tasked to produce defense equipments and make profit. While they do get fully protected by assured orders from MOD for meeting the requirements of the armed forces without any competition, they can also get into license agreements for development and manufacturing fairly independently. They need not depend on DRDO or private industry to meet their obligations and commitments. They are driven by turnover, profit, bonus, employment, and expanding their footprints across the country.

DRDO is the only government agency authorized and empowered to carry out R&D for defense. This is in contrast to defense R&D being carried out in private industry in most of the countries, like in Europe or in the USA. Sometimes R&D in industry is funded by their respective governments, but many times the company invests for its own products. These companies have been able to recover their investments through military sales and sometimes through sales to civilian market based on military technologies. While R&D, manufacturing, and production of defense system are integrated in one company in most parts of the world, DRDO does not have this luxury. They can only develop and test prototypes and prove their working. Subsequently, they need to be manufactured by industry (private and public) and ensured that the products work as good as during development. It requires enormous technical and managerial skills to make this happen.

It is also to be appreciated that the production agencies have their tooling, manufacturing, and assembly strengths, while DRDO has core strength in design, innovation, testing, development, integration, and evaluation. However, one should sense the fact that there is a gap between end of R&D at DRDO for any weapon, e.g., missile system, combat aircraft, radar, or tank, and beginning of serial production at DPSUs. The engineering and productionization are more than mere transferring of drawings, assembly details, and testing. It appears that both DRDO and DPSUs are not good at this interfacing step! It is seen that most of the delays and failures happen here.

Let us consider the role and responsibilities of users, the triservices, and the coast guard. They need weapons today as they face threats and challengers. They cannot wait for DRDO to develop or DPSU to produce. They would prefer to buy a proven and readily available product. Added to the availability, there is strong marketing biz by weapon suppliers from many countries because India is the biggest weapon market in the world.

Then there are MOD officials, the key decision makers in defense acquisition. These MOD officials are mostly bureaucrats who have no real stake in the happenings. They would be happy to ensure procedures, transparency, probity, and fair play. Thus, it is seen that pride of ownership is not there anywhere except in DRDO who are the creators of new weapon system and who would like to see them ordered, deployed, and used.

Driving Needs

Even in such a complex ecosystem, there is a driving need for a workable model for the Indian defense industry. The Minister of Defence and the GOI have been time and again demanding more and more of self-reliance in the defense area. Drivers are many for such a demand. Some of them are listed below:

1. Independence from foreign suppliers – this is the most important as our defense policies, strategies, and doctrines are not to be decided by other countries through their weapons, their capabilities, limitations, supply chain, logistics, and operational doctrines. The foreign weapons, most of the time, are supplied in bulk, and India would have to stock them, maintain them, and keep refurbishing and updating hoping one day there would be a sudden requirement. In most of the cases, these weapons get either time expired as there would have been no war or technologically obsolete in this fast-changing world. Then there would be a perpetual dependence on foreign suppliers, and we may never be able to come out of foreign clutches, in addition to sacrificing the national pride and compromising national security simultaneously. After all the supplier of weapons would know the limitations of their weapons and their key classified parameters. Such a vital information could be accessed by own adversaries with some effort.
   How can we value building of our own weapons and pride of fielding them and fighting with them? Can we fight a war with imported soldiers?

Technology for the Country and Security for the Nation

When we spend thousands of crores of rupees in the country for developing technologies to be integrated into our weapons, we are actually investing on Indian soil. The funds get into our academic institutions, R&D labs, and defense industries. New materials and processes would be discovered, new designs and models would be innovated, new hardware and software would be created, new facilities and infrastructure would be established, and new human resource would be generated! If in some cases these are not created totally new, they are surely modernized and upgraded.

Thus, when new defense products get developed and deployed, the technologies that got germinated and nurtured are also available to Indian industries for exploitation in civilian products. There are modern communication systems, new materials, state-of-the-art manufacturing processes, smart sensors and actuators, intelligent algorithms and better software, and more efficient gadgets, clothing, medicines, food items, and accessories which have come out of investment in defense. Such spin-offs could be piloted by DRDO or initiated by industries. Thus, the country will have technologies while simultaneously security is being assured for defending our nation.

Defense Technologies and Employment

Employing the large population of present and continuous supply of qualified youth in the country is a big challenge to our government. Though a very high percentage of population is engaged in agriculture and related activities (nearly 70%), it is very inefficient and of low productivity. But this percentage is decreasing every year and may stabilize to around 10% considering the fact that this figure is below 5% in developed countries.

Next big employer is in services sector which has grown over the last two decades and has saturated. This is expected to stay around 25%. There is thus an inescapable requirement of growth in employment potential in manufacturing sector. Let us analyze this potential.

In low- and high-volume mass manufacturing, China and some of the other Asian countries have overtaken India in productivity and cost-effectiveness. In the other end of very high-tech manufacturing like microelectronics, machinery, and test equipment, the Western world has established itself as suppliers to entire world, exception being Japan, South Korea, and Thailand. Countries like Bangladesh, Sri Lanka, and Vietnam have overtaken India in textiles and dresses. Thus, it is seen that space and maneuverability available to India have shrunk and index of industrial production is constantly decreasing. One area where India can possibly grow is in defense sector.

World-Class Defense Products

The defense system developed in the country by DRDO is state of the art and of world class, whether we are talking of missile systems or combat aircraft or radar systems or torpedoes or sonars or engineering equipment or C^4I systems or unmanned aircraft or life-support systems or tanks. They are well designed; they employ latest technologies and materials and have been field evaluated in the most stringent conditions. They are cost competitive and fully customized to meet requirements of our armed forces and battlefield conditions.

The only concern is that they are not produced in large numbers due to various technological and managerial constraints and made available in time.

Breakthroughs in Mass Production

There is a need to understand all the limitations and constraints in mass production of defense systems and manage them better. The concerns expressed by the government and especially the armed forces are the following:

1. Defense systems produced by Indian industry lack quality and reliability.
2. Timely deliveries and product support are poor.
3. Product upgrades and obsolescence management need attention.

Definitely these issues need to be addressed. The inherent lacunae in Indian defense development and production are to be understood and corrective actions taken up. The biggest issue is that the R&D and production entities, i.e., DRDO and DPSUs (including OFs), are under independent departments though under the same Ministry of Defence. And there exists a gap as brought out earlier.

This gap becomes all the more significant when we see that all the defense products are of latest technologies and designed for extreme operating conditions and the embedded technologies need to be fully understood and appreciated. Only then can the development and production of products be managed well.

Technology: Hard and Soft

Technology needs to be fully understood. Normally, set of drawings, tooling, jigs and fixtures, and assembly procedures are considered as components of "technology." It is not so. One has to add to this design know-how, expert manpower, testing and measuring systems, standards, processes for manufacturing at all stages, and associated software packages to make "technology" complete.

Robert Phaal from University of Cambridge adds another dimension by bringing in a concept of "soft technology." What we have so far defined above, he calls them as "hard technology" and specifies that "soft technology" encompasses various processes like management techniques employed, design and innovation processes generated and used, leadership, teamwork, attitude, knowledge sharing, organization structure required and used for generating technology, network found necessary to support, and skill processes. Thus, both hard and soft technologies need to be handled and managed well leading to successful technology management. As it can be seen, hard technologies constitute explicit knowledge whereas soft technologies are predominantly tacit or implicit knowledge (Fig. 1).

DIAT and Technology Management

The Defence Institute of Advanced Technology at Pune is evolving a unique system of education and training to assimilate and manage defense technologies in Indian context. The peculiarities and distinctive characteristics of various limbs of defense system in the country as brought out earlier in this chapter have been understood and assimilated. DIAT has configured and evolved a methodology and process of bringing in and implementing a customized technology management (with innovation and project management embedded in it) process for the Ministry of Defence. DIAT will be offering postgraduate MBA degree in defense technology management. This will be followed up by PhD and targeted training for DRDO scientists, engineers from DPSUs, OFs, and private players. Even officials from MOD and other departments of GOI can participate in this program. This setup can also be tasked to evolve specific solutions for challenges and problems encountered by any of the stakeholders.

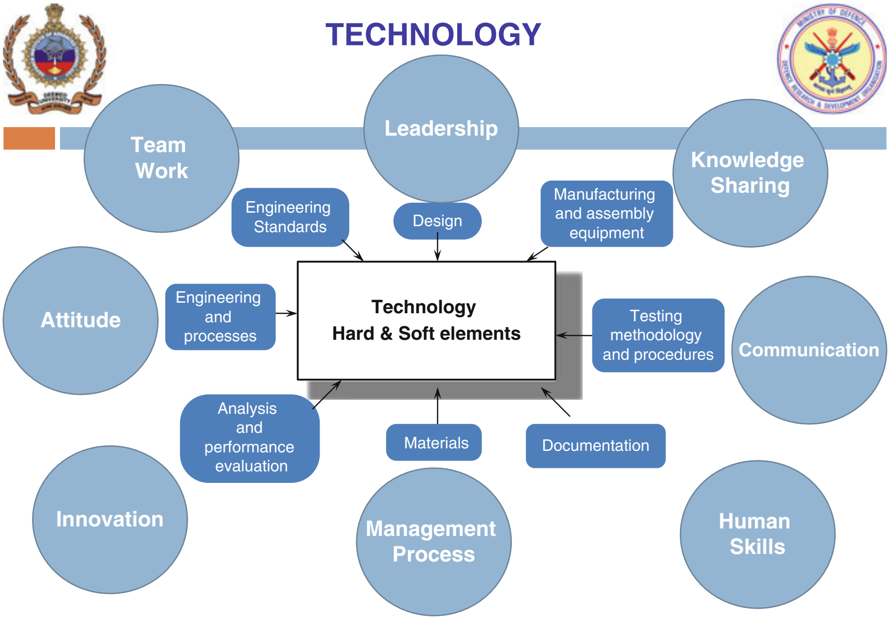

Fig. 1 Technology – Hard and Soft elements

Case Studies

It is essential to realize that a successful technology management effort results not only in realizing the correct technology (technologies) that goes into the product but also that the product is realized in time. There is a practical case in Indian defense system wherein two missile projects were taken up simultaneously under the same program but technology management teams were different.

It so happened that though project Trishul realized most of its specified objectives, there was an unacceptable delay from user point of view. Users therefore resorted to, at some point of time, buying from abroad a similar system at much higher cost depriving the country foreign exchange and employment potential.

The 2nd missile system Akash could meet the users' expectations and ended up as a successful project with huge induction orders. Impact of this decision by MOD on Indian industry over the next 20 years will be enormous because of volume of production and subsequent continuous product support but also technology content and skill sets that get established in the process. In the process of technology management, Indian academy, DRDO, other S&T institutions, a large number of private industries, and global consultants have been involved, engaged, and harnessed by the project team.

Conclusion

Importance of well-conceived technology management in defense scenario specific to Indian context has been analyzed here. Strengths and limitations of various players and stakeholders have been brought out. Case studies are available for knowledge sharing and corrective actions. Road map for bringing in an appropriate technology management culture and discipline has been enunciated.

Acquiring Gilead Sciences as a Proposed Strategy for Merck & Co. Growth

Derek Haacker, Cory Nolan, and Venkatachalam Seshan

Introduction

The pharmaceutical industry holds significant financial value and presents lucrative opportunities as it is projected to grow to $1.1 trillion in ethical (prescription) drug sales by 2014 (Saftlas 2010). These sales are expected to increase at a compound annual growth rate in the 5–8% range, as global sales grew 7% to $837 billion in 2009, an increase from 5.3% growth in 2008 (Saftlas 2010). Merck & Co. is one of the top ten largest global pharmaceutical companies, with net sales of $27.4 billion and net income of $13 billion, giving it a 3.39% share of the global market (Anon 2010). With drugs in each of the five market segments (cardiovascular, central nervous system, internal medicine, oncology, and anti-infectives/vaccines), Merck offers a diversified portfolio of drugs treating the illnesses detrimental to the quality of human life. The magnitude of this industry creates intense competition for share of market. Top competitors for Merck include Johnson & Johnson, Pfizer, Novartis, Sanofi-Aventis, GlaxoSmithKline, and AstraZeneca; these companies alone control 40% of the global pharmaceutical market (Anon 2010).

Although Merck merged with Schering-Plough in October 2008, in an attempt to create a robust product pipeline and lower overhead costs, its market share remains lower than other top ten competitors (Anon 2011e). In April 2010, blockbuster drugs Cozaar and Hyzaar lost patent exclusivity, creating additional pressures on Merck's profitability. This exemplifies competition from generics, which introduces downward pressure on drug pricing, known as generic erosion (Anon 2011e). Additionally, the 2010 Healthcare Reform Bill, which expands Medicare Part D

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Discount Programs and creates other pharmaceutical discount programs, will further erode profit margins. To counteract this, Merck increased research and development expenditures by $1 billion in 2009 to replenish a deteriorating product portfolio (Anon 2011e). Its current product pipeline includes 19 products in phase III clinical trials and 4 in final review (Anon 2011e).

Understanding Merck's current position and industry trends, as well as the increasing presence and demand for biotechnologies, the need to increase its presence in the valuable cardiovascular and central nervous system (CNS) segments by implementing biologics becomes a realizable strategy. Reflected in Sanofi-Aventis' recent acquisition of Genzyme on February 16, 2011, the third largest biotechnology company by revenue, Merck's need to expand into the biotech industry is similar to its competitors, and a viable opportunity exists through the acquisition of Gilead Sciences, Inc. (Sovich and Mannella 2011).

Gilead Sciences is a competitive and successful global biotechnology company with presence in both the biotechnology and pharmaceutical industries. In 2009, Gilead achieved sales of $6.5 billion and a net income of $2.6 billion in 2009, giving it a 2.9% share of market globally and making it the fifth largest biotechnology company (Anon 2011c). Having a long presence and success in the anti-infectives market segment, Gilead has increased its research and development (R&D) and product pipelines in the cardiovascular and CNS segments in recent years (Anon 2011c).

Through pro forma financial statement forecasts, including cumulative discounted net cash flows, and the employment of scenarios for characterizing the External Environment and the Pharmaceutical Industry and the Environmental Threats and Opportunities Profile (ETOP), the acquisition of Gilead was analyzed to determine financial strength and probability of success for this proposed strategy. Analysis through six benchmarking evaluative measures determines profitability, and overall success probability considerations concluded this acquisition was the most profitable and successful strategy in comparison to others proposed.

Critical Issues

Merck must expand operations and sales, or it will continue to lose market share and face stagnant revenues. Due to its internal weaknesses, particularly following the generic erosion of Cozaar and Hyzaar, Merck needs a stronger position in the cardiovascular and central nervous system (CNS) market segments to maintain pace and improve position relative to competitors (Anon 2011e). These two segments are the two largest, each valued at $120 billion in 2009 (Saftlas 2010).

There are critical issues that must be addressed if Merck wants to maintain and grow its market share. The first of these issues is its expiring patents and generic erosion, resulting in 95% revenue losses per drug, an impact especially felt by blockbuster drugs. In the pharmaceutical industry, a blockbuster drug is defined as achieving over $1 billion in annual sales. Merck's two blockbuster cardiovascular drugs, Cozaar and Hyzaar, lost patent protection in April 2010, resulting in downward pressure on Merck's sales. Merck's 2009 revenues from the cardiovascular segment were $4.7 billion, a sizable 17% of the total product portfolio revenue (Anon 2011e). However, this value is currently not sustainable; included in this value are blockbuster drugs Cozaar and Hyzaar, collectively valued over $3 billion (Anon 2011e). Adjusting the revenues for the loss of these drugs in 2010, as well as others in the following 4 years, the segment generates $440 million, a significantly smaller 1.6% of all revenues. These revenue figures rank Merck 9th of the top ten pharmaceutical giants for 2009, a position it needs to improve to capture a large portion of the valuable cardiovascular segment (Anon 2011e). Without a strong and diverse pipeline, Merck will not be able to introduce new, innovate drugs to strengthen its position in this segment. Similarly, the CNS segment generated $1.2 billion for Merck in 2009, ranking it 7th of the top ten companies in revenue, and currently without significant depth in the current product pipeline, especially concerning when considering increasing demand (Anon 2010).

A second critical issue Merck faces is the growing market need for cardiovascular and CNS medicine. Inherently, the dominant size of these segments is reflective of the high demand of these ethical drugs to treat common illnesses that decrease the quality of life. The most rapidly growing demographic segment is the over-85 age group, a demographic with the highest need for such medicines (Saftlas 2010). This segment is exposed to CNS diseases, such as Alzheimer's and Parkinson's disease, at significantly higher rates than other age segments. As the number of these cases increase, not only will drug demand rise, but so will a demand fueled by consumers for cutting-edge solutions allowing more effective treatment. Additionally, increasing occurrence of obesity globally is detrimental to cardiovascular health and will place an upward pressure on the demand for cardiovascular drugs (Saftlas 2010).

A third critical issue Merck must address is the expansion of its competitors into the biotech industry. With Sanofi-Aventis' current attempt to acquire biotech Genzyme, the trend of pharmaceutical-biotech company partnerships and acquisition is growing in the industry (Saftlas 2010). Other companies are projected to follow suit, and Merck must act quickly to begin developing its market share within the biotech industry. This is an industry where both quality and timeliness of products are imperative for success. Billions of dollars are invested annually toward discovering and implementing the latest and greatest advances in pharmaceutical and biotechnology. With competition and politics-driven regulations helping generic erosion, as the top two external threats to companies, strength in the product pipeline is vital to ensure the introduction of innovative new products to replace those at the end of the product life cycle.

Recommended Strategy

The most effective method of acquiring Gilead Sciences is to buy out the first 51% of Gilead in the first year, 2011, as presented in this strategy. Based on Gilead's market capitalization of $30.76 billion (as of February 11, 2011), this will cost

$15.69 billion without any negotiation. Gilead's stock price as of February 11, 2011, was $38.35, and its total shares outstanding were 802 million. Negotiation for the takeover will be aided by the healthy relationship existing between Merck and Gilead, stemming from a history of collaborative business efforts. In the past, they have collaborated to improve R&D, drug development and production, and global distribution chains to deliver products to under-reached countries (Anon 2008). Further, looking ahead, each company stands to gain increased efficiency and effectiveness by combining resources. The size of Merck and available capital will improve Gilead's drug distribution, as its biologics will immediately strengthen Merck's product portfolio and pipeline. This healthy relationship, in combination with mutually beneficial and shared resources, will result in a negotiated takeover of 51% of Gilead for $14.9 billion in 2011.

Merck will continue to purchase a larger ownership stake in Gilead in the 3 years following the initial buyout, ultimately seeking 100% of Gilead. In the second year, 2012, Merck will buy an additional 25% of Gilead for $7.31 billion, in year three it will buy another 15% for $4.38 billion, and in year four, 2014; the buyout will be finalized and completed by purchasing the final 14% for $4.09 billion. The total amount of money spent by Merck on the acquisition will be $30.58 billion. Using a discount rate of 10% to discount the purchases in 2012–2014, the total discounted amount that Merck will spend on acquiring Gilead is $28.23 billion.

Acquiring 51% of Gilead in 2011, Merck will obtain ownership control of the company immediately. By purchasing the minimum for ownership, Merck is able to defer half of the cost of the acquisition to future years. This is beneficial and necessary for Merck's commitment to R&D, as resources will continue to be available and used for its own drugs over the 3 years, rather than experiencing a detrimental drop in R&D in this period. Structuring the takeover over 4 years, Merck is able to maintain and grow its expenditures in R&D while acquiring a biotech company with cardiovascular and CNS drugs currently in the pipeline.

Justification

Analysis of Merck's current financial position reveals opportunities for growth amidst a challenging and rapidly changing current environment. The current global pharmaceutical market faces downward pricing and sales threats from regulatory agencies, competition for share of market between pharmaceuticals as well as generic companies, and sweeping healthcare reform enacted by the administration of President Obama. Employing the WOTS-UP Matrix, similar to a SWOT analysis, but with strategies for future growth, a general analysis of Merck's current position was obtained (Rowe et al. 2010). Specific opportunities exist within the areas of biological treatments, sustained size and profitability of the cardiovascular and CNS market segment, and slowly increasing purchasing powers of a greater population promoted by the resurgence from a weakened recessionary economy. Merck possesses strengths in product value, diversity in growth, and a strong reputation and customer association with reliability and quality. Its weaknesses include a weak market position in the cardiovascular and CNS market segments, particularly after a loss of patent exclusivity of existing blockbusters Cozaar and Hyzaar.

Primarily, it is imperative that Merck acquires an expertise in biotechnology, which can then be applied in continuing to develop drugs within the cardiovascular and CNS segments. Gilead accomplishes both of these goals with remarkable success; it is a biotechnology company that has experienced large profit growth and is investing increasing amounts of R&D dollars and manpower in the cardiovascular and CNS segments, seeking continual success in the largest market segments (Anon 2011c). Focus on these segments is evident in Gilead's recent acquisitions of CV Therapeutics, Inc. and CGI Pharmaceuticals in 2009 and 2010, respectively (Anon 2011b). CV Therapeutics brings with an expertise in cardiovascular drugs, such as Ranexa and Lexiscan, as well as technologies bridging the gap between traditional pharmaceuticals and biotechnology. Research expertise provided by CGI Pharmaceuticals is imperative for the development of CNS drugs in the future, specifically in kinase biology and chemistry (Anon 2011d). Each of these two acquisitions represents Gilead's focus and dedication to the cardiovascular and CNS segments, which are imperative to Merck's success as well. Gilead, like Merck, has proven its strategy to increase market share through increased knowledge and technologies exhibited in a diverse portfolio of drugs.

Gilead is noted among the biotech firms for having a strong current product pipeline in the cardiovascular segment and growing research and development of other segments, including the CNS. With revenues of $6.5 billion from product sales in 2009 alone, Gilead is already profitable and strong as an individual entity, but may lack resources to successfully employ enough R&D to bring all products from the pipeline to the marketplace (Anon 2011c). The combination of Merck's vast pool of resources with Gilead's specialized research and development technology and strength in the cardiovascular and central nervous system segments, the two companies show a strong strategic fit potential. Furthermore, the similarity in mission and goals between the pharmaceutical and biotechnical industries make them compatible partners.

The initial cost of the takeover, $14.9 billion, is a realistic negotiated value, particularly when considering that Merck will provide capital, ensuring the sustainability and full implementation of the products in Gilead's product pipeline. Such drugs are vital to the success and increased market share of each company, creating a beneficial position for each to take through negotiations.

The timing of this acquisition is another important factor that fits the strategies of each company. Merck, in a statement to shareholders on February 6, 2011, announced that it will maintain its dedication to R&D growth in the coming years, despite the recent economic turmoil that has affected the global economy. While other pharmaceuticals, such as Pfizer, have announced opposite strategies to cut R&D expenses by condensing pipeline projects, Merck has made clear its mission to continue growth (Loftlus 2011). Acquiring Gilead accomplishes just this, and the timing now creates further financial incentives for Merck. With the stock market continuing to slowly recover from the past 3 years, Merck is able to acquire Gilead at a lower cost than in a fully recovered economy. While many companies may be responding to the current economy with slowed down spending on acquisitions and R&D, Merck has an ideal opportunity to surpass its competition by expanding its technological core competencies with the addition of new R&D initiatives, as well as established and successful products capitalizing on biologics.

Implementation Plan

The acquisition of Gilead will be initiated with the negotiation of the terms of acquisition. In this phase, Merck will make its bid to acquire Gilead for the amount it has valued the biotechnology company. Merck will highlight the specific reasons that the acquisition is mutually beneficial and that the price is fair, considering the intangible benefits of acquisition. Merck will argue that its increased capital and availability of R&D and labor resources will increase the efficiency and effectiveness of development, production, and marketing of the drugs currently in Gilead's pipeline. The price of the buyout is realistic and rational based on the current stock price and market capitalization of Gilead.

Once acquisition terms are mutually agreed upon, Merck will begin the process of taking operating control of Gilead. Throughout the merging phase of the acquisition, there will be a significant number of layoffs in response to the overlap in responsibilities, whether in R&D, production, or marketing. After the restructuring of positions and roles, Merck must evaluate and assess current projects in the new, overall pipeline. Based on its strategic goals and the collaborative resources available, the viability and success of each project must be weighed, ultimately deciding which projects to be pursued and allocated funding, meaning some projects will be dropped. Addressing the critical issues within the cardiovascular and CNS segments, Merck will allocate significant resources and funding to projects in these segments. Each already has projects in progress, and new opportunities will arise to combine available technologies and fully utilize the expertise each brings to the acquisition.

Merck will complete the acquisition of Gilead over 2012–2014. Over these 3 years, Merck's available funds for R&D will be counterbalanced by the required funds to complete the acquisition. Increased revenues from Gilead will provide Merck with new opportunities to invest in R&D, and this will require strategic evaluations in which initiatives in new drugs to pursue. The basis for this acquisition is to strengthen Merck's position in the cardiovascular and CNS segments by implementing biologics; however, it is vital to remember that Gilead will also provide expertise in the anti-infectives segment, specifically in HIV research, and this expertise will be appropriately applied to existing R&D, resulting in cutting-edge biologics in multiple segments.

Analysis of Environmental Threats and Opportunities Profile

Consideration was given to the overall strategic fit of Gilead's operations within Merck by performing an Environmental Threats and Opportunities Profile (ETOP) evaluation. Environmental scanning analyzes trending factors that present opportunities and threats for the pharmaceutical industry. These factors are technology, international, politics, social, ecology, energy, economics, competition, and spirit/ethics/spirituality, collectively known as TIPSEEECS. The industry is continually shaped through interaction with its environment, placing value on understanding TIPSEEECS factors. Companies must operate in adaptation to these environmental factors, seizing opportunities and guarding against threats (Rowe et al. 2010).

Through a quantitative evaluation process, TIPSEEECS factors are ranked by which present the most lucrative industry opportunities and the most dangerous threats. Each TIPSEEECS factor is quantitatively evaluated according to its impact (from very negative to very positive) and importance (from least important to most important). This process generates the Environmental Threats and Opportunities Profile, ETOP, for the industry. As TIPSEEECS factors continually evolve, the Environmental Threats and Opportunities Profile must be periodically reevaluated such that the a company has a current understanding of which environmental factors require attention for sustainability within the industry (Rowe et al. 2010). All of the TIPSEEECS factors affect the pharmaceutical industry, Merck and Gilead; however, those dimensions with greatest influence are technology, social, and competition, which will be discussed in this section.

The single greatest threat facing both Merck and Gilead is competition. The pharmaceutical industry earns a return more than 11% over the S&P Industrial Average, making it one of the most profitable, hence most competitive industries. There are two predominant aspects of this completion. One of the patent exclusivity sides is where R&D is a battle between major pharmaceutical innovators, with billions of dollars invested in future drugs and technology. The other side involves competition once patent exclusivity ends, when pharmaceutical companies must defend their products against lower-cost generic alternatives that appear on the market (Rowe et al. 2010).

Among branded, prescription drugs, there is fierce competition among companies to develop the next patentable drug. By market share, the top four firms in the pharmaceutical industry have market shares within 4% of each other – and a total market share of 23%, leaving 77% of the industry to all other companies, each possessing less than 3.7% (Saftlas 2010). There is intense competition among these companies for single-digit market share points with billions of dollars at stake.

As branded, prescription drugs lose their patent exclusion, and in some cases become available over the counter (OTC), marketing and selling the drug becomes increasingly vital to the drug's success. Once generics are available, the price of the drug immediately drops often by as much as 90%. These sales dollars remain important for pharmaceutical companies as they continually invest money into R&D for future patent-protected drugs – the cycle continues.

Mergers and acquisitions (M&A) have historically been an important factor in the pharmaceutical industry, as firms seek to combine their technologies and core competencies to increase synergies and profits. Both large and small firms stand to benefit through mergers and alliances as large firms are able to reach new market segments and the small firms increase their R&D budgets. Similarly, through partnerships with foreign firms, successful drugs in one country can be introduced and marketed in new countries with greater ease (Saftlas 2010).

Technology represents the opportunity for pharmaceuticals to address the challenges of competition. Patent protection is vital to the success of the pharmaceutical industry, encouraging companies to continue to invest money in research and development (R&D) by guaranteeing a period of time to earn a return on investments in drugs. The industry scored a victory over generic drugs as patent-marketing exclusivity of new biotech drugs was granted for 12 years. Currently, the pharmaceutical industry earns 20% of its revenue from biologics, and it is expected that nearly half of the top 100 drugs in 2014 will be biotech products. In 2010, biologics expenditures represent nearly one third of all pharmaceutical R&D and global sales of just under $115 billion (Saftlas 2010).

Despite these positives, the pharmaceutical industry stands to lose $142 billion in sales, 17% of global sales in 2009, as patent exclusivities expire and generics of popular drugs begin production and sales (Saftlas 2010). In preparations for this, R&D has been reshaped within the industry, with firms focusing on areas of expertise and fast-growing segments, such as biologics and vaccines. R&D productivity presents a challenge to the industry; despite increasing dollar amounts invested in R&D, the number of major new drug launches has trended downward in the past decade (Saftlas 2010).

As major populations increase, life expectancy lengthens, and chronic diseases become more widespread, social trends are moving in a positive direction for the pharmaceutical industry. A larger population is a larger user group for all drugs produced, and the elderly population segment is especially important to the pharmaceutical industry. In many Western countries, the elderly population is growing at a greater rate than the general population, which is a positive trend for pharmaceuticals. By 2050, people aged 60 or higher will account for 22% of the world's population, an increase from 10.9% in 2009 (Saftlas 2010). In the next 20 years, people aged 65 or older will grow to 79.3 million from 41.7 million in 2010, as the baby boomer population pushes the American population of people over 65–26% by 2030 from 13 % in 2010. The pharmaceutical industry can expect increased demand for drugs as the population over 65 accounts for nearly one third of all drug consumption (Saftlas 2010).

Emerging markets present new opportunities as new levels of disposable incomes make drugs now affordable, but at the same time introduce chronic diseases to the population. There is a cycle in which availability and affordability of drugs in these markets has increased life expectancy and population, which increases the demand for other drugs. As these populations live longer and at a new standard, they have been introduced to Western diseases, such as cardiovascular disease (CVD), cancer, and diabetes, but other diseases that are behaviorally caused, including obesity and smoking. Such behaviors present vast, new opportunities for the pharmaceutical industry (Saftlas 2010).

Procedures for Collecting Data

Using market trends, as well as historical data, and a modified Excel formula that is based on a linear regression model, the income statement and balance sheet data for Gilead were forecasted for 19 years into the future. The forecasted market growth trends represented similar market trends for the next 19 years, with cyclicality, as the industry has no strong external forces that would cause a significant reduction in future growth. This data was used to calculate a discounted cumulative cash flow figure to determine the profitability of the proposed strategy in terms of net present value [NPV]. Additional consideration was given through the employment of ETOP and its analysis of significant external factors exerting the highest levels of influence on the profitability and success of Gilead (Rowe et al. 2010). Finally, an overall consideration was given to the comparison of the acquisition of Gilead strategy with the managerial strategies of Merck and its desires to continue increasing revenues and income, recapturing lost market share.

Current data was attained by using current and historical 10-K Annual Reports for each of the entities. Future projections were reflective of the current positions of the company and the most recent historical trends seen in revenue and income data subject to business cyclicality.

Results

Examining Gilead's sales data from the past 10 years allows for sales projections for the 19 years presented in this strategy. The high growth rates from 2002 to 2009 are not sustainable at sales levels over $6 billion; the projected sales figures from 2011 to 2029 will grow at realistic rates between 2 and 12% (Exhibit 1).

With these sales figures projected through 2029, they will be used in forecasting net income over the 19 years presented in this strategy. Gilead's sales projections are inserted directly into the pro forma income statements for 2011–2029, which show forecasted future growth rates, net sales figures, and resources allocated to research and development (Seshan 2010). These financial statements forecast future income of the company, and other key data such as research and development, which must be considered in Merck's overall evaluation of the strategy (Exhibit 2).

Pro forma income statement analysis shows the forecasted net income of nearly $6 billion by 2029; this gives annual growth rates of 12–27%, which is significantly higher than the 2–10% growth rate currently seen in the pharmaceutical industry. The forecasted research and development data shows the difficulty that Gilead will have in future years holding on to valuable resources that will be spent on expanding

Exhibit 1 Historical sales data and sales forecast, 2001–2029

Year	Sales ($MM)	Growth Rate
2001	191.00	
2002	423.90	121.94%
2003	836.30	97.29%
2004	1,242.30	48.55%
2005	1,809.30	45.64%
2006	2,588.20	43.05%
2007	3,733.10	44.24%
2008	5,084.75	36.21%
2009	6,469.63	27.24%
2010	6,063.17	-6.28%
2011	6,312.85	4.12%
2012	6,753.61	6.98%
2013	7,299.85	8.09%
2014	8,074.23	10.61%
2015	9,098.74	12.69%
2016	10,179.81	11.88%
2017	11,336.12	11.36%
2018	12,293.57	8.45%
2019	12,827.43	4.34%
2020	13,158.12	2.58%
2021	13,602.98	3.38%
2022	14,290.66	5.06%
2023	15,032.83	5.19%
2024	15,966.29	6.21%
2025	16,354.98	2.43%
2026	17,987.63	9.98%
2027	18,130.26	0.79%
2028	19,632.47	8.29%
2029	21,016.31	7.05%

research and development. This stresses the value of Merck's larger command of resources to Gilead's continued growth.

Pro forma balance sheet figures were forecasted for the same time period to determine the forecasted strength of financial position of Gilead (Rowe et al. 2010). It was realized that important data to consider when evaluating the overall strength and growth potential were property, plant and equipment, and net working capital.

The investments in property, plant, and equipment and reductions in debt are necessary to improve Gilead's financial position. The increase in the capacity to

Exhibit 2 Pro forma income statement (2011–2029)

$MM	2011	% of Sales	2012	% of Sales	2013	% of Sales	2014	% of Sales	2015	% of Sales	2016	% of Sales
Growth Rate												
Net Sales	6,312.85	100%	6,753.61	100%	7,299.85	100%	8,074.23	100%	9,098.74	100%	10,179.81	100%
COGS	1,704.47	27%	1,688.40	25%	1,824.96	25%	1,937.82	24%	2,183.70	24%	2,239.56	22%
Gross Margin	4,608.38	73%	5,065.21	75%	5,474.89	75%	6,136.41	76%	6,915.04	76%	7,940.25	78%
Additional Capital Expenditures for capacity growth to support Net Sales												
S,G&A	2,146.37	34%	2,363.76	35%	2,481.95	34%	2,745.24	34%	3,002.58	33%	3,257.54	32%
R&D	1,287.82	20%	1,411.50	21%	1,562.17	21%	1,752.11	22%	2,038.12	22%	2,382.08	23%
Depreciation Expense	44.44	1%	60.00	1%	82.20	1%	108.50	1%	139.97	2%	179.16	2%
Operating Expenses	3,478.63	55%	3,835.27	57%	4,126.32	57%	4,605.85	57%	5,180.67	57%	5,818.78	57%
(TCOS) Total Cost of Sal	5,183.10	82%	5,523.67	82%	5,951.28	82%	6,543.67	81%	7,364.37	81%	8,058.33	79%
Operating Income (EBIT)	1,129.75	18%	1,229.94	18%	1,348.57	18%	1,530.56	19%	1,734.37	19%	2,121.48	21%
Taxes	395.41	6%	430.48	6%	472.00	6%	535.70	7%	607.03	7%	742.52	7%
Net Income	734.33	12%	799.46	12%	876.57	12%	994.87	12%	1,127.34	12%	1,378.96	14%

$MM	2017	% of Sales	2018	% of Sales	2019	% of Sales	2020	% of Sales	2021	% of Sales	2022	% of Sales
Growth Rate			8%		4%		3%		3%		5%	
Net Sales	11,336.12	100%	12,293.57	100%	12,827.43	100%	13,158.12	100%	13,602.98	100%	14,290.66	100%
COGS	2,493.95	22%	2,212.84	18%	2,052.39	16%	1,710.56	13%	1,632.36	12%	1,429.07	10%
Gross Margin	8,842.17	78%	10,080.73	82%	10,775.04	84%	11,447.56	0%	11,970.62	88%	12,861.59	90%
Additional Capital Expenditures for capacity growth to support Net Sales												
S,G&A	3,622.38	32%	3,999.11	33%	3,848.23	30%	3,684.27	28%	3,400.75	25%	3,001.04	21%
R&D	2,777.35	25%	3,122.57	25%	3,334.90	26%	3,486.90	27%	3,727.22	27%	3,972.80	28%
Depreciation Expense	223.95	2%	270.98	2%	325.18	3%	383.71	3%	445.10	3%	507.42	4%
Operating Expenses	6,623.69	58%	7,392.66	60%	7,508.31	59%	7,554.89	57%	7,573.07	56%	7,481.26	52%
(TCOS) Total Cost of Sal	9,117.63	80%	9,605.50	78%	9,560.70	75%	9,265.44	70%	9,205.42	68%	8,910.33	62%
Operating Income (EBIT)	2,218.49	20%	2,688.07	22%	3,266.73	25%	3,892.68	30%	4,397.56	32%	5,380.33	38%
Taxes	776.47	7%	940.82	8%	1,143.36	9%	1,362.44	10%	1,539.14	11%	1,883.12	13%
Net Income	1,442.02	13%	1,747.24	14%	2,123.38	17%	2,530.24	19%	2,858.41	21%	3,497.22	24%

$MM	2023	% of Sales	2024	% of Sales	2025	% of Sales	2026	% of Sales	2027	% of Sales	2028	% of Sales	2029	% of Sales
Growth Rate	5%		6%		2%		10%		1%		8%		7%	
Net Sales	15,032.83	100%	15,966.29	100%	16,354.98	100%	17,987.63	100%	18,130.26	100%	19,632.47	100%	21,016.31	100%
COGS	1,352.95	9%	1,436.97	9%	1,471.95	9%	1,439.01	8%	1,450.42	8%	1,766.92	9%	1,681.30	8%
Gross Margin	13,679.88	91%	14,529.32	91%	14,883.03	91%	16,548.62	92%	16,679.84	92%	17,865.55	91%	19,335.01	92%
Additional Capital Expenditures for capacity growth to support Net Sales														
S,G&A	3,006.57	20%	3,033.60	19%	2,780.35	17%	3,057.90	17%	2,900.84	16%	3,141.20	16%	3,152.45	15%
R&D	4,194.16	28%	4,534.43	28%	4,808.36	29%	5,198.43	29%	5,511.60	30%	6,066.43	31%	6,599.12	31%
Depreciation Expense	573.38	4%	618.59	4%	656.09	4%	682.59	4%	717.04	4%	745.98	4%	731.63	3%
Operating Expenses	7,774.11	52%	8,186.61	51%	8,244.80	50%	8,938.91	50%	9,129.48	50%	9,953.60	51%	10,483.19	50%
(TCOS) Total Cost of Sal	9,127.06	61%	9,623.58	60%	9,716.75	59%	10,377.92	58%	10,579.90	58%	11,720.53	60%	12,164.50	58%
Operating Income (EBIT)	5,905.77	39%	6,342.71	40%	6,638.23	41%	7,609.71	42%	7,550.36	42%	7,911.94	40%	8,851.81	42%
Taxes	2,067.02	14%	2,219.95	14%	2,323.38	14%	2,663.40	15%	2,642.63	15%	2,769.18	14%	3,098.13	15%
Net Income	3,838.75	26%	4,122.76	26%	4,314.85	26%	4,946.31	27%	4,907.73	27%	5,142.76	26%	5,753.68	27%

bring multiple products out of the development pipeline and to the marketplace will require capital investments in addition to what will be generated by income. The additional capital needed is not great enough to discourage the acquisition of Gilead; however, it enables Merck to emphasize its added value to Gilead, which increases its pricing leverage in negotiating the acquisition.

By using the pro forma financial statements, the total permanent investment and working capital as well as annual changes with the data were forecasted for the future 18 years (Rowe et al. 2010). High investments are necessary in the pharmaceutical and biotechnical industry due to high overhead costs. Positive annual changes reflect a strengthening of financial position and ability to complete the product development life cycle and bring products to market.

As is seen in Exhibit 3, there are positive changes in total permanent investment, mainly due to the increases in the next 19 years in property, plant, and equipment because it is necessary to increase capacity levels and technological advances to maintain a positive sales growth rate. Also, positive changes in working capital show positive cyclical improvement on the financial position of the company.

Exhibit 3 Pro forma balance sheet (2011–2029)

Item	2011	%TA	2012	%TA	2013	%TA	2014	%TA	2015	%TA	2016	%TA
$MM	**Assets**											
Current Assets:												
Cash	1,304.30	27%	1,552.12	26%	1,831.50	26%	2,142.85	25%	2,464.28	25%	2,784.64	24%
Accounts Receivables	1,692.40	34%	2,013.96	34%	2,376.47	33%	2,780.47	33%	3,197.54	32%	3,613.22	31%
Inventories	1,169.35	24%	1,391.53	23%	1,642.00	23%	1,921.14	23%	2,209.31	22%	2,496.52	22%
Total Current Assets	4,166.05	85%	4,957.60	84%	5,849.97	82%	6,844.46	81%	7,871.13	79%	8,894.38	77%
Property, Plant & Equipment	800.00	16%	1,080.00	18%	1,479.60	21%	1,953.07	23%	2,519.46	25%	3,224.91	28%
Less: Accumulated Depreciation	44.44	1%	104.44	2%	186.64	3%	295.15	3%	435.12	4%	614.28	5%
Net P,P & E Assets:	755.56	15%	975.56	16%	1,292.96	18%	1,657.92	19%	2,084.34	21%	2,610.63	23%
Total Assets	4,921.61	100%	5,933.16	100%	7,142.92	100%	8,502.39	100%	9,955.48	100%	11,505.01	100%
	Liabilities											
Current Liabilities:												
Accounts Payable	975.00	20%	983.60	17%	995.40	14%	1,005.70	12%	1,019.40	10%	1,035.70	9%
Other Liabilities	2,437.50	50%	2,360.64	40%	2,289.42	32%	2,212.54	26%	2,140.74	22%	1,967.83	17%
Total Current Liabilities:	3,412.50	69%	3,344.24	56%	3,284.82	46%	3,218.24	38%	3,160.14	32%	3,003.53	26%
Net Working Capital (NWC)	753.55	15%	1,613.36	27%	2,565.15	36%	3,626.22	43%	4,710.99	47%	5,890.85	51%
Long-Term Liabilities:												
Long-Term Debt	1,155.00	23%	1,364.63	23%	1,571.44	22%	1,785.50	21%	1,991.10	20%	2,301.00	20%
Total Liabilities	4,567.50	93%	4,708.87	79%	4,856.26	68%	5,003.74	59%	5,151.24	52%	5,304.53	46%
	Stockholders' Equity											
Stockholders' Equity:												
Retained Earnings from Strategy	354.11	7%	1,224.29	21%	2,286.66	32%	3,498.64	41%	4,804.24	48%	6,200.48	54%
Total Stockholders' Equity	354.11	7%	1,224.29	21%	2,286.66	32%	3,498.64	41%	4,804.24	48%	6,200.48	54%
Total Liabilities & Stockholders' Equity:	4,921.61	100%	5,933.16	100%	7,142.92	100%	8,502.39	100%	9,955.48	100%	11,505.01	100%

Item	2017	%TA	2018	%TA	2019	%TA	2020	%TA	2021	%TA	2022	%TA
$MM	**Assets**											
Current Assets:												
Cash	3,090.95	24%	3,245.49	23%	3,634.95	23%	4,034.80	22%	4,397.93	22%	4,705.79	22%
Accounts Receivable $MM	4,010.67	31%	4,211.21	30%	4,716.55	29%	5,235.37	29%	5,706.55	29%	6,106.01	29%
Inventories	2,771.14	21%	2,909.70	21%	3,258.86	20%	3,617.34	20%	3,942.90	20%	4,218.90	20%
Total Current Assets	9,872.76	76%	10,366.40	73%	11,610.37	72%	12,887.51	72%	14,047.38	71%	15,030.70	70%
Property, Plant & Equipment	4,031.14	31%	4,877.68	35%	5,853.22	37%	6,906.80	38%	8,011.88	40%	9,133.55	43%
Less: Accumulated Depreciation	838.23	6%	1,109.21	8%	1,434.39	9%	1,818.10	10%	2,263.21	11%	2,770.63	13%
Net P,P & E Assets:	3,192.91	24%	3,768.47	27%	4,418.82	28%	5,088.69	28%	5,748.67	29%	6,362.92	30%
Total Assets	13,065.67	100%	14,134.86	100%	16,029.19	100%	17,976.20	100%	19,796.05	100%	21,393.62	100%
	Liabilities											
Current Liabilities:												
Accounts Payable	1,197.50	9%	974.50	7%	997.50	6%	1,004.60	6%	1,016.90	5%	1,036.40	5%
Other Liabilities	2,035.75	16%	1,656.65	12%	1,695.75	11%	1,677.68	9%	1,647.38	8%	1,647.88	8%
Total Current Liabilities:	3,233.25	25%	2,631.15	19%	2,693.25	17%	2,682.28	15%	2,664.28	13%	2,684.28	13%
Net Working Capital (NWC)	6,639.51	51%	7,735.25	55%	8,917.12	56%	10,205.22	57%	11,383.10	58%	12,346.42	58%
Long-Term Liabilities:												
Long-Term Debt	2,482.48	19%	2,685.62	19%	3,045.55	19%	3,235.72	18%	3,563.29	18%	3,850.85	18%
Total Liabilities	5,715.73	44%	5,316.77	38%	5,738.80	36%	5,918.00	33%	6,227.57	31%	6,535.13	31%
	Stockholders' Equity											
Stockholders' Equity:												
Retained Earnings from Strategy	7,349.94	56%	8,818.09	62%	10,290.39	64%	12,058.20	67%	13,568.49	69%	14,858.49	69%
Total Stockholders' Equity	7,349.94	56%	8,818.09	62%	10,290.39	64%	12,058.20	67%	13,568.49	69%	14,858.49	69%
Total Liabilities & Stockholders' Equity:	13,065.67	100%	14,134.86	100%	16,029.19	100%	17,976.20	100%	19,796.05	100%	21,393.62	100%

Item	2023	%TA	2024	%TA	2025	%TA	2026	%TA	2027	%TA	2028	%TA	2029	%TA
$MM	**Assets**													
Current Assets:														
Cash	5,035.19	22%	5,538.71	22%	5,926.42	23%	6,222.74	23%	6,502.76	23%	6,782.38	24%	7,087.59	24%
Accounts Receivable	6,533.43	28%	7,186.78	29%	7,689.85	29%	8,074.34	30%	8,437.69	30%	8,800.51	31%	9,196.53	31%
Inventories	4,514.22	20%	4,965.64	20%	5,313.24	20%	5,578.90	21%	5,829.95	21%	6,080.64	21%	6,354.27	22%
Total Current Assets	16,082.85	70%	17,691.13	71%	18,929.51	72%	19,875.99	74%	20,770.41	75%	21,663.53	76%	22,638.39	77%
Property, Plant & Equipment	10,320.91	45%	11,249.79	45%	11,924.78	45%	12,401.77	46%	13,021.86	47%	13,542.73	48%	14,084.44	48%
Less: Accumulated Depreciation	3,344.01	15%	3,962.60	16%	4,618.69	18%	5,301.28	20%	6,018.32	22%	6,764.29	24%	7,495.92	26%
Net P,P & E Assets:	6,976.89	30%	7,287.19	29%	7,306.09	28%	7,100.49	26%	7,003.54	25%	6,778.44	24%	6,588.52	23%
Total Assets	23,059.74	100%	24,978.32	100%	26,235.60	100%	26,976.47	100%	27,773.94	100%	28,441.97	100%	29,226.91	100%
	Liabilities													
Current Liabilities:														
Accounts Payable	1,065.40	5%	1,087.40	4%	1,106.50	4%	1,124.10	4%	1,126.40	4%	1,131.40	4%	1,135.40	4%
Other Liabilities	1,576.79	7%	1,435.37	6%	1,327.80	5%	1,247.75	5%	1,070.08	4%	825.92	3%	715.30	2%
Total Current Liabilities:	2,642.19	11%	2,522.77	10%	2,434.30	9%	2,371.85	9%	2,196.48	8%	1,957.32	7%	1,850.70	6%
Net Working Capital (NWC)	13,440.65	58%	15,168.36	61%	16,495.21	63%	17,504.14	65%	18,573.93	67%	19,706.21	69%	20,787.69	71%
Long-Term Liabilities:														
Long-Term Debt	4,381.35	19%	4,745.88	19%	4,722.41	18%	4,855.77	18%	4,999.31	18%	5,119.55	18%	5,260.84	18%
Total Liabilities	7,023.54	30%	7,268.65	29%	7,156.71	27%	7,227.62	27%	7,195.79	26%	7,076.88	25%	7,111.55	24%
	Stockholders' Equity													
Stockholders' Equity:														
Retained Earnings from Strategy	16,036.20	70%	17,709.67	71%	19,078.89	73%	19,748.86	73%	20,578.15	74%	21,365.09	75%	22,115.37	76%
Total Stockholders' Equity	16,036.20	70%	17,709.67	71%	19,078.89	73%	19,748.86	73%	20,578.15	74%	21,365.09	75%	22,115.37	76%
Total Liabilities & Stockholders' Equity:	23,059.74	100%	24,978.32	100%	26,235.60	100%	26,976.47	100%	27,773.94	100%	28,441.97	100%	29,226.91	100%

Exhibit 4 Permanent income worksheet (2011–2029)

Year	Net Sales	Property, Plant & Equipment	R & D	Total Permanent Investment	Change in Permanent Investment	Working Capital	Change in Working Capital
2011	6,312.85	800.00	1287.82	2087.82	2087.82	754	754
2012	$ 6,754	1080.00	1411.50	2491.50	403.68	1613.36	859.81
2013	$ 7,300	1479.60	1562.17	3041.77	550.26	2565.15	951.79
2014	$ 8,074	1953.07	1752.11	3705.18	663.41	3626.22	1,061.07
2015	$ 9,099	2519.46	2038.12	4557.58	852.40	4710.99	1,084.77
2016	$ 10,180	3224.91	2382.08	5606.99	1049.41	5890.85	1,179.86
2017	$ 11,336.12	4031.14	2777.35	6808.49	1201.50	6639.51	748.66
2018	$ 12,293.57	4877.68	3122.57	8000.25	1191.76	7735.25	1,095.74
2019	$ 12,827.43	5853.22	3334.90	9188.12	1187.87	8917.12	1,181.87
2020	$ 13,158.12	6906.80	3486.90	10393.70	1205.58	10205.22	1,288.11
2021	$ 13,602.98	8011.88	3727.22	11739.10	1345.40	11383.10	1,177.88
2022	$ 14,290.66	9133.55	3972.80	13106.35	1367.25	12346.42	963.32
2023	$ 15,032.83	10320.91	4194.16	14515.07	1408.72	13440.65	1,094.23
2024	$ 15,966.29	11249.79	4534.43	15784.21	1269.15	15168.36	1,727.71
2025	$ 16,354.98	11924.78	4808.36	16733.14	948.93	16495.21	1,326.85
2026	$ 17,987.63	12401.77	5198.43	17600.19	867.05	17504.14	1,008.92
2027	$ 18,130.26	13021.86	5511.60	18533.45	933.26	18573.93	1,069.79
2028	$ 19,632.47	13542.73	6066.43	19609.16	1075.71	19706.21	1,132.29
2029	$ 21,016.31	14084.44	6599.12	20683.56	1074.40	20787.69	1,081.48

The total cash outflow on an annual basis was calculated by using the annual change in permanent investment and working capital. This was then compared to the total cash inflow generated by depreciation expenses and total net income. The difference of these two numbers on an annual basis calculated the net cash flow for that year's activities. From this data, cumulative cash flows could be calculated.

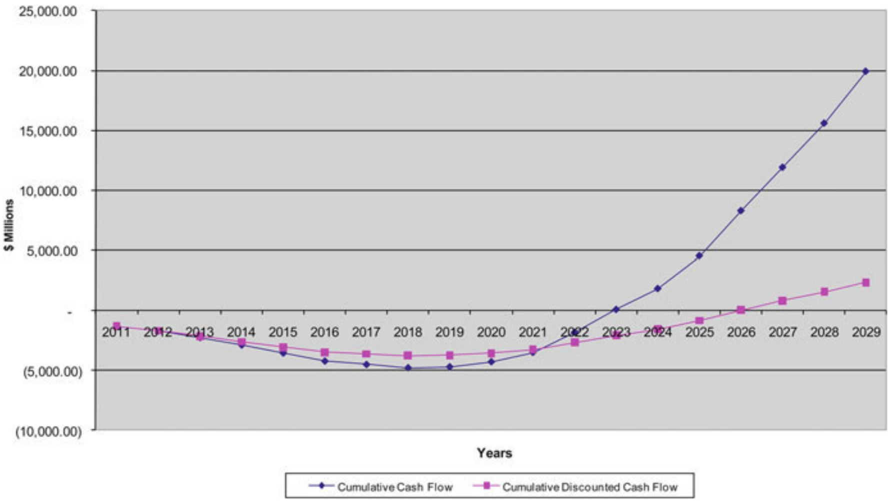
Each of these numbers was then discounted at a discount rate of 10%, assuming a 6.5% average weighted cost of capital, to facilitate this leveraged growth. These calculations are depicted in Exhibit 4 (Seshan 2010). A final graph was then prepared to show the magnitude and timeline of cash flows for Gilead over the next 19 years to be used as an evaluative measure for the acquisition by Merck, as is shown in Exhibit 5 (Rowe et al. 2010) (Exhibit 6).

The discounted cumulative cash flows become positive in 2026. This shows that the investments throughout the coming years will continue increasing research and development and property, plant, and equipment and will generate positive cash flows by 2026. The improvements will be made possible with the increase in resources provided by Merck in the acquisition. This added capital will generate cumulative positive cash flows of $2.3 billion by 2029. The cumulative positive cash flow is critical when evaluating the viability and profitability of the implementation of this strategy because it shows the profitability generated by the acquisition of Gilead for Merck's stakeholders. Additionally, the acquisition has a positive NPV when discounted back for the 19 years including all expenditures and investments for Merck.

Exhibit 5 Cash flow forecasts (2011–2029)

Year	Change in Permanent Investment	Change in Net Working Capital	Cash Outflow	Depreciation	Net Income	Cash Inflow	Net Cash Flow	Cumulative Cash Flow	Discounted Net Cash Flow @ 10%	Cumulative Discounted Cash Flow @ 10%
	P,P&E+R&D	(NWC)2 - (NWC)1 Change in NWC	(Change in Permanent Investment + Change in Net Working Capital)	(Straight-Line)		(Depreciation + Net Income)	(Cash Inflow-Cash Outflow)			
2011	2087.82		2,087.82	44.44	734.33	778.78	(1,309.04)	(1,309.04)	(1,309.04)	(1,309.04)
2012	403.68	859.81	1,263.49	60.00	799.46	859.46	(404.03)	(1,713.07)	(367.30)	(1,676.34)
2013	550.26	951.79	1,502.05	82.20	876.57	958.77	(543.28)	(2,256.35)	(448.99)	(2,125.34)
2014	663.41	1,061.07	1,724.49	108.50	994.87	1,103.37	(621.12)	(2,877.47)	(466.65)	(2,591.99)
2015	852.40	1,084.77	1,937.17	139.97	1,127.34	1,267.31	(669.86)	(3,547.33)	(457.52)	(3,049.51)
2016	1049.41	1,179.86	2,229.26	179.16	1,378.96	1,558.12	(671.14)	(4,218.47)	(416.73)	(3,466.24)
2017	1201.50	748.66	1,950.16	223.95	1,442.02	1,665.97	(284.19)	(4,502.67)	(160.42)	(3,626.66)
2018	1191.76	1,095.74	2,287.49	270.98	1,747.24	2,018.23	(269.27)	(4,771.94)	(138.18)	(3,764.84)
2019	1187.87	1,181.87	2,369.74	325.18	2,123.38	2,448.55	78.82	(4,693.12)	36.77	(3,728.07)
2020	1205.58	1,288.11	2,493.69	383.71	2,530.24	2,913.95	420.26	(4,272.86)	178.23	(3,549.84)
2021	1345.40	1,177.88	2,523.28	445.10	2,858.41	3,303.52	780.23	(3,492.62)	300.81	(3,249.02)
2022	1367.25	963.32	2,330.57	507.42	3,497.22	4,004.64	1,674.07	(1,818.55)	586.75	(2,662.27)
2023	1408.72	1,094.23	2,502.95	573.38	3,838.75	4,412.13	1,909.18	90.63	608.32	(2,053.95)
2024	1269.15	1,727.71	2,996.86	618.59	4,122.76	4,741.35	1,744.50	1,835.12	505.32	(1,548.63)
2025	948.93	1,326.85	2,275.77	656.09	4,314.85	4,970.94	2,695.17	4,530.29	709.72	(838.91)
2026	867.05	1,008.92	1,875.98	682.59	4,946.31	5,628.90	3,752.92	8,283.21	898.42	59.51
2027	933.26	1,069.79	2,003.05	717.04	4,907.73	5,624.77	3,621.72	11,904.93	788.19	847.70
2028	1075.71	1,132.29	2,207.99	745.98	5,142.76	5,888.74	3,680.75	15,585.68	728.22	1,575.92
2029	1074.40	1,081.48	2,155.88	731.63	5,753.68	6,485.30	4,329.43	19,915.10	778.69	2,354.61

Exhibit 6 Cash flow forecasts graph (2011–2029)



Conclusions

With a positive NPV for the strategy, in addition to positive cumulative discounted cash flows in 16 years from the point of investment, the acquisition of Gilead is a competitive strategy to positively position Merck for overall growth in market share, especially in the cardiovascular and central nervous system market segments (Rowe et al. 2010). Not only is the acquisition sound from a financial standpoint, representing strategic profitability and positive discounted cumulative cash flows in just 16 years for Merck, it would also give them access to the increasingly important biotechnologies and research that can be used to bolster R&D for all other product segments. Currently, Merck's only source of biotechnologies is from the prior merger with Schering-Plough which is very limited. The acquisition of Gilead would also grant Merck access to Gilead's developing HIV and anti-infectives market segment, which may be the next revolutionary development in the healthcare and medical industries.

The current market cap of Gilead, Inc. is $30.76 billion which Merck will be able to negotiate in its offer price of Gilead due to Gilead's increased need for capital in the future as evidenced by the pro forma financial statements previously discussed (Anon 2011c). This allows the forecast of a purchase price of 95% of current market cap. With that calculation, the initial investment will cost Merck $15.69 billion to acquire a 51% stake in Gilead Sciences, Inc., with the remaining 49% to be acquired in the following 3 years. This will allow Merck to use existing resources to help complete the product development phase for many drugs in its own pipeline and in Gilead's, increasing cash flows from operations, while the acquisition is taking place.

Merck must act strategically and competitively if it wants to retain and improve its current position among the top ten global pharmaceutical companies. By pursuing an acquisition of Gilead, Merck will be a front-runner in the pursuit of blending pharmaceutical development with biotechnical research. Pursuing successful products in the cardiovascular and central nervous system market segments will also uphold Merck's commitment to social responsibility and ethics in the marketplace in seeking to improve the well-being and livelihood of the public.

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