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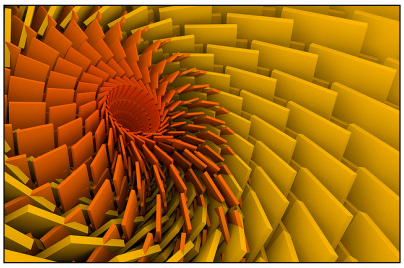

Managing Innovation for Tangible Performance

Welcome to the October 2013 issue of the *Technology Innovation Management Review*. This month's editorial theme is Managing Innovation for Tangible Performance. We welcome your comments on the articles in this issue as well as suggestions for future article topics and issue themes.

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Overview

The *Technology Innovation Management Review* (TIM Review) provides insights about the issues and emerging trends relevant to launching and growing technology businesses. The TIM Review focuses on the theories, strategies, and tools that help small and large technology companies succeed.

Our readers are looking for practical ideas they can apply within their own organizations. The TIM Review brings together diverse viewpoints – from academics, entrepreneurs, companies of all sizes, the public sector, the community sector, and others – to bridge the gap between theory and practice. In particular, we focus on the topics of technology and global entrepreneurship in small and large companies.

We welcome input from readers into upcoming themes. Please visit timreview.ca to suggest themes and nominate authors and guest editors.

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Contribute to the TIM Review in the following ways:

- Read and comment on past articles and blog posts.
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Editorial:
Managing Innovation for Tangible Performance

Chris McPhee, Editor-in-Chief
Sorin Cohn, Guest Editor

From the Editor-in-Chief

Welcome to the October 2013 issue of the *Technology Innovation Management Review*. This is our second issue on the editorial theme of Managing Innovation for Tangible Performance, and I am pleased to welcome back our guest editor, **Sorin Cohn**, President of BD *Cohn*sulting Inc.

With this issue, the TIM Review celebrates its second birthday! In October 2011, this journal was re-launched as the *Technology Innovation Management Review*, thereby replacing the *Open Source Business Resource*, which was launched in July 2007. Coinciding with this milestone, we just surpassed our target of 10,000 unique visitors per month (timreview.ca/article/569), which represents a doubling of our readership in the past year. Special thanks to our readers, authors, guest editors, reviewers, advisors, and sponsors for their contributions to our success so far!

Our theme in November will be Living Labs, and our guest editors will be **Seppo Leminen**, Principal Lecturer at the Laurea University of Applied Sciences, Finland, and **Mika Westerlund**, Assistant Professor at Carleton University's Sprott School of Business in Ottawa, Canada. Also note that we are continuing our annual tradition of focusing our January issue on the theme of Open Source Business. Please get in touch if you are interested in contributing an article on this topic.

Finally, we encourage you to attend the upcoming International Seeking Solutions Summit (i3s-conference.com) and to participate as an "expert problem solver" in the Quebec Seeks Solution Event (quebecinternational.ca/qss) on November 5 and 6 in Quebec City, Canada. The best papers from the conference will published in a future issue of the TIM Review. See our March 2013 issue for details of the Seeking Solutions approach to local open innovation (timreview.ca/issue/2013/march).

We hope you enjoy this issue of the TIM Review and will share your comments online. Please contact us (timreview.ca/contact) with article topics and submissions, suggestions for future themes, and any other feedback.

From the Guest Editor

In this second of two issues on Managing Innovation for Tangible Performance, our authors share insights on increasing the competitiveness of firms, meeting market needs by tailoring external innovations, managing innovation throughout a company's lifecycle, collaborating with partners in product development, fostering innovation literacy through applied research, and programming innovative thinking into company culture.

In the first article, I introduce an innovation management framework and assessment tool to help firms increase their competitiveness. This framework and its associated tool provide both large and small companies with an effective methodology for devising competitive management strategies based on an assessment of their competitive status and by monitoring their progress towards improved market positions. Thus, they enable the corporate leadership to decide on priorities for competitive development, adopt appropriate innovation strategies to meet corporate goals, monitor progress, make adjustments, and help create and maintain a culture of innovation that is aligned with business goals.

Next, **Jeff Moretz**, **Karthik Sankaranarayanan**, and **Jennifer Percival** from the University of Ontario Institute of Technology encourage us to not shy away from "reinventing the wheel" when it comes to leveraging external innovation and existing technologies to create products or services that cater to the market needs. They present a three-pillar model for bringing innovations to market successfully and profitably by focusing on market-oriented development, technological development capacity, and organizational capacity. Their article includes examples of companies that attained market success in large part by contextualizing existing technologies in order to create innovative products or services.

Tamas Koplyay from the Université du Québec en Outaouais in Gatineau, Canada, and **Lisa Chillingworth** and **Brian Mitchell** from Szent István University in Budapest, Hungary, present a model that incorpor-

Editorial: Managing Innovation for Tangible Performance

Chris McPhee and Sorin Cohn

ates the effect of leadership and organizational culture upon the evolution of innovation during the firm's market lifecycle. They argue that the management of innovation requires a wide spectrum of approaches with different levels of interventions through the firm's lifecycle. Their model graphically illustrates four dimensions of innovation upon which management focus to varying degrees in step with the firm's progression through the lifecycle.

John Thomson from Thoven Consulting and **Vince Thomson** from McGill University share insights into the use of agile, cooperative techniques to maintain daily communication among numerous internal and partner engineers to better coordinate product design and system integration. With a focus on boundary management (i.e., inter-team relationships and communication), they contrast conventional models of product development with a modern, collaborative approach, which today's companies need to make their product development efforts successful when working with partners.

Robert Luke from George Brown College in Toronto, Canada, examines how colleges and polytechnic institutes are fostering innovation literacy via support for business innovation. He argues that there are two key benefits from colleges conducting applied research with industry partners: industry gains access to talent and support to launch new products and services into the marketplace, and students gain innovation skills through their participation in applied research, which ultimately increases the innovation potential of the workforce. He then presents a logic model, which shows the approach used by George Brown College in developing a framework for measuring this innovation potential with a long-term, outcomes-based analysis.

Finally, **Tim Ragan**, the founder/owner of C-View Strategies, answers the question "How do you program innovative thinking into company culture?". He discusses how executive teams can program the "strategy setting" aspect of innovative thinking into their business and foster a culture of experimentation. He shares five practical steps to help companies intentionally build a culture of innovation within their own organization.

When we combine the insights of these six contributions with those from the articles in the September issue (timreview.ca/issue/2013/september), we see that Michael Porter was right to highlight the fact that "innovation is the central issue in economic prosperity" (1980; tinyurl.com/ms52o7c) – especially in the context of fiercely competitive globalized markets. However, "innovation without methodology is just luck", as Morris Langdon (2006; tinyurl.com/lkfbyxw) has stated so succinctly. Innovation is much more than just technology and R&D. A company's success depends more on market-worthy competitive pursuits and a culture that supports business goals and chosen innovation strategies.

Firm-level innovation comprises the entire portfolio of innovation activities carried out by the firm, and its management aims to maximize the benefits to the corporation in the context of competitive markets and finite corporate resources. Effective management of firm-level innovation is a multi-stage process that addresses, among others, the needs to:

1. Adopt and use an effective firm-level innovation management process based on a well chosen framework of innovation and effective management tools and metrics, as demonstrated by Cohn in this issue.

2. Ensure vision, will, and the means to proceed forward, including the necessary funding for innovation projects (see the article by Hurwitz in the September issue: timreview.ca/article/725). Collaboration is necessary to supplement internal resources and more and more companies take advantage of their partners to achieve critical innovation goals, as discussed by Thomson and Thomson in this issue. Companies need to understand and take advantage of their "innovation ecosystem" – a topic covered by Watters in the September issue (timreview.ca/article/727). Also, universities and colleges need to deliver better training to the next generation of innovators and business leaders, as exemplified by Luke in this issue.

3. Determine the competitive imperatives through targeted assessments (see Cohn in this issue) and business model investigations for achieving leadership differentiation and growth in the market. This approach may necessitate broadening the definition of value and wealth to include non-financial aspects of market performance, as shown by Brousseau-Gauthier and Brousseau in the September issue (timreview.ca/article/726).

4. Select innovation strategies and priority innovation goals, which should go beyond the usual considerations of product innovations to cover resources, culture, organization, corporate processes, and market-interaction innovations. As highlighted by Legrand and LaJoie in the September issue (timreview.ca/article/724), service innovation is becoming more important in the context of the global knowledge eco-

Editorial: Managing Innovation for Tangible Performance

Chris McPhee and Sorin Cohn

nomy and requires special attention in Canada. Moretz, Sankaranarayanan, and Percival also point out in this issue the benefits of, and methodologies for, effective exploitation of external innovations and existing technologies.

5. Organize, measure and execute the chosen innovation projects with due attention on time management to avoid missing critical market windows or running out of financial means, as discussed by Crawhall in the September issue (timreview.ca/article/723).

6. Review, learn, adjust, and continue, because competition never ends and innovation must be pursued relentlessly to avoid lifecycle pitfalls and decline, as discussed by Koplyay, Chillingworth, and Mitchell in this issue.

7. Establish and maintain a culture of innovation that permeates all corporate levels, is aligned with corporate goals and performance-evaluation systems for human resources, and operates symbiotically with risk management. Addressing this need effectively requires inculcation of innovative thinking into company culture (see Ragan's contribution in this issue) and the mastering of the art and science of transformation, as described by Schroeder in the September issue (timreview.ca/article/722).

In summary, innovation needs to be managed strategically and methodically for tangible corporate (and national) performance where it matters: in the global marketplace.

So, can one innovate innovation? Our answer is an unqualified *yes*.

Sorin Cohn
Guest Editor

Chris McPhee
Editor-in-Chief

About the Editors

Chris McPhee is Editor-in-Chief of the *Technology Innovation Management Review*. Chris holds an MASc degree in Technology Innovation Management from Carleton University in Ottawa and BScH and MSc degrees in Biology from Queen's University in Kingston. He has over 15 years of management, design, and content-development experience in Canada and Scotland, primarily in the science, health, and education sectors. As an advisor and editor, he helps entrepreneurs, executives, and researchers develop and express their ideas.

Sorin Cohn has 35 years of international business and technology experience, having been involved in most facets of innovation development: from idea to research and lab prototype, from technology to product, and then to market success on the global stage. He has developed new technologies, created R&D laboratories, started new product lines, and initiated and managed new business units. Sorin has several essential patents in web services, wireless, and digital signal processing, as well as over 70 publications and presentations. He has also been Adjunct Professor at the University of Ottawa. He is a Killam Scholar, and he holds a PhD in Electrical Engineering, an MSc in Physics, and an MEng in Engineering Physics. Sorin is President of BD *Cohn*sulting Inc. As well, he acts as Leader of Innovation Metrics at The Conference Board of Canada and as Chief Program Officer of i-CANADA. He is also Member of the Board of Startup Canada as well as the Board of the Centre for Energy Efficiency.

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A Firm-Level Innovation Management Framework and Assessment Tool for Increasing Competitiveness

Sorin Cohn

> *"I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be."*
>
> Lord Kelvin (1824–1907)
> Mathematical physicist and engineer

Innovation depends on much more than just technology and R&D. It is a means to an end – competitive success and higher market value – and it needs to be managed strategically and methodically for tangible corporate performance where it matters: in the market. This article introduces a comprehensive corporate innovation management framework (v-CIM) and a targeted competitiveness assessment tool (i-TCA). Properly used by corporate leaders, this framework and its associated tool enable innovation managers to decide on priorities for competitive development, adopt appropriate innovation strategies to meet corporate goals, monitor progress, make adjustments, and help create and maintain a culture of innovation that is aligned with business goals.

Introduction

Firms innovate to create value and maintain or enhance their competitive position in the market. Their attitude towards innovation, the types of innovation they pursue, and the levels of risk they accept depend on the situation of the firm in its market. Firm-level innovation is not a goal in itself, but the means to achieving corporate success and higher market value, which are predicated on:

1. A market of sufficient size or growth.

2. The competitiveness of the firm in serving its market, as determined by: i) the desirability and affordability of the firm's products and services; ii) the effectiveness of the firm's interactions with the market in terms of understanding it, promoting to it, collaborating with suppliers and partners, accessing its targeted customers, and satisfying its customers and the other stakeholders; iii) the efficiency of the firm's operations (e.g., management, development, production, human resources, quality, distribution, supply, marketing); and iv) the firm's financial strength.

3. The culture of the organization, including leadership, skills competencies, etc.

4. Luck and timing, which are imponderable ingredients recognized by business leaders and military strategists from time immemorial.

Comprehensively, innovation is the process by which a firm creates value and differentiation through new or improved products or services, or new ways of pursuing the business goals and its operations – both within the organization and throughout its entire business environment. For a long time, managing innovation has been an art that is now becoming more of a science based on objective data and proven methodologies.

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

The broad spectrum of a firm's innovation goals and the interdependencies between various domains of innovation present numerous challenges to attempts at managing firm-level innovation effectively and efficiently. First, it is necessary for the firm to decide to *compete through innovation* and determine *where* to innovate. Then, it needs to select *what* to innovate, allocate the resources, organize each of the innovation activities as a project, and plan *how* to pursue them. The firm management must also determine how to evaluate its innovation activities and the overall innovation performance: *what* to measure and *how* to measure it. Once the innovation efforts are underway and results are being evaluated, the firm should decide on necessary adjustments (including project termination or change of direction), as well as *who* to reward and *how*. Because competition is perennial, firm-level innovation management is a continuous process, and the firm needs to extract as much learning from the present before proceeding anew to decide on *where*, *when*, and *how* to innovate next.

Innovation may be driven top-down by defining innovation strategies to be followed, planning the respective innovation projects, resourcing them, executing and evaluating them, and finally ensuring their implementation and commercialization. Innovation may also flow bottom-up, in which case it should be adopted, nurtured, managed, and rewarded to encourage more innovations to bloom.

Some of the main difficulties in managing firm-level innovation are due to inconsistent understanding (and models) of innovation and the lack of adequate measurement-based management methodologies and tools. Innovation is complex and multidimensional, and many firms have let important innovations languish or were incapable of maintaining their competitive position through continued innovation (Christensen, 1997; tinyurl.com/7onvohk).

Traditionally, innovation research focused on three dimensions: the source of the innovation (internal or external), the type of innovation (product, service, or process innovation), and the rationale for the innovation (voluntary initiative or a necessity demanded by competitive pressures in the market). Inadequate attention has been given to the interaction between innovation and the firm's organization and to the multitude of factors affecting innovation, some of which may be external to the firm itself (Tidd, 2001; tinyurl.com/pdtcuov).

An effective pursuit of market competitiveness through innovation requires a corporate leadership that is open to critical assessments of the company's position in the market and an organization prepared to strategically address necessary innovation pursuits based on realistic measurements of progress. Firm-level innovation management for competitive growth involves a multistage process that addresses:

1. Strategic competitiveness assessment and planning, including the determination of competitive imperatives, innovation strategies, specific innovation goals, and expected targets.

2. Establishing and maintaining a culture of innovation that permeates all corporate levels, is aligned with corporate goals and human-resources performance-evaluation systems, and operates symbiotically with risk management.

3. Adopting and using an effective firm-level innovation-management process based on a well-chosen model of innovation and effective management tools and metrics.

4. Pursuing continuous learning and adjustment that addresses both innovation activities and the choice of tools and metrics for fast adaptation to the changing needs of the company.

Systematically driving a company in its competitive progress requires an innovation-management framework that looks comprehensively at the complex multidimensional reality of the various domains of innovation within the firm. These management needs have been the impetus for the development – over the past 15 years of the author's business-development work with large and small firms in Canada, the United States, and Europe – of a firm-level innovation-management framework and an associated tool for the assessment of a company's competitive position in its targeted markets.

This article introduces the Value-Added Corporate Innovation Management (v-CIM) framework enabling a firm's leadership to undertake innovation activities strategically in a balanced approach across all the critical domains of competitiveness. Next, the paper outlines the importance of matching corporate vision and goals with a workable understanding of the competitive reality. On that basis, the paper presents the Intelligent Targeted Competitiveness Assessment (i-TCA) tool developed by the author. Several examples of real company assessments are described to illustrate the application and usefulness of the i-TCA tool.

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

Innovation Management Models

Various models of the innovation process have been offered in the literature to help firms manage their innovation activities with proper measurement techniques and tools. Initially, the focus was on the individual innovation process, as seen in the Linear Model (Davila et al., 2005; tinyurl.com/k86rs47), the Innovation Team Model (Källman, 2009; tinyurl.com/m23elnf), and the Innovation Value Chain (Hansen and Birkinshaw, 2007; tinyurl.com/m2bd8ko). These models have the merit of facilitating the management of individual innovation projects, but they do not enable an overall strategic look at innovation throughout the firm.

The contribution from external actors to the ideation, implementation, and commercialization of innovation has taken a greater significance in the context of the World Wide Web and globalization. The concept of "open innovation" (Chesbrough, 2003; tinyurl.com/kp33d22) is preoccupying strategists attempting to deliver the best ways to take advantage of, and defend against, the threats brought by the "democratization of innovation" (von Hippel, 2006; tinyurl.com/aygvzd2).

Firm-level innovation management requires models that enable prioritization of innovation activities and resource allocation in the context of present and future competitive needs.

The Business Growth Model was developed by Arthur D. Little to position innovations in a strategic context (Collins and Smith, 1999; tinyurl.com/m4p6jh7). It addresses innovation holistically by considering strategic issues on a par with the other domains of innovation as four interdependent elements. The model enables answers to – and measurements of – the fundamental issues of innovation in a firm:

- Are the right things being addressed? (Stakeholder Strategies)
- Are these things done right? (Processes)
- Are there the necessary means and capabilities? (Resources)
- Does the firm get the best from its resources? (Organization and Culture)

The associated metrics require a time perspective for balancing past achievements with predictive measurements of potential innovation outcomes through corporate capabilities.

The Idea Funnel Model (Goffin and Mitchell, 2005; tinyurl.com/nydxx3s) pays more attention to the importance of innovation strategies in determining the selection, direction and execution of innovations, but it still does not consider all corporate capabilities or the importance of innovation in strategy itself.

The Structural Perspective Model (Muller et al., 2005; tinyurl.com/mzcub7x), further developed by InnovationPoint (Kaplan and Winby, 2007; tinyurl.com/p49twxy), looks at innovation from a capability, resource, and leadership view in an attempt at balancing all critical factors in the selection and management of innovations from inception to market valuation.

The more mathematically formal Axiomatic Design Model of the "innovation continuum" (Suh, 2010; tinyurl.com/ov9dfgo) was developed as a fully engineered process that starts from functional requirements and delivers design parameters. This model is focused on new products and services in a continuum of 12 essential steps necessary to take the idea to its completion as product in the market. The model has met with some success in helping South Korea develop its capabilities in the industrial sectors it considered essential for competitive domination.

Another model of merit is the INNOVAT10N Model (tinyurl.com/ke7m9n5), which was developed by Doblin in 1998 and was updated in 2011. This model focuses on 10 types of innovations that, if properly intertwined and managed, enable companies to develop competitive offerings aimed at generating higher returns thanks to insidious values that are more difficult to be copied entirely. The problem with this model is that it does not address certain areas of innovation explicitly – especially those related to corporate capabilities starting with culture, the organization, the variety of resources, and the processes that keep the corporation in action.

"Culture is key" was the conclusion of the recent studies by Booz & Co on innovation and competitiveness in industry (Jaruzelski et al., 2011; tinyurl.com/lrtvbnm), with the corollary that a culture of innovation and the alignment of business goals with the right innovation strategies are more determinant factors than the amount of investments in research and development programs.

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

The 3M Company (2011; tinyurl.com/ppcd3ly) has developed its own model for managing innovation as a matrix interlacing the "outcomes" (i.e., products and services, marketing and customers, territories, technologies, etc.) with the key organizational structures (R&D, marketing, national sales, operations, human resources, culture, etc.) in an effort to ensure that it is "planned, purposeful, and global".

Value-Added Corporate Innovation Management Framework

Managing a company requires a framework that looks comprehensively at the multidimensional intertwined reality of the various domains of innovation within the firm, thus allowing the firm's leadership to manage innovation strategically in a balanced approach across all the critical domains of competitiveness. The Value-Added Corporate Innovation Management (v-CIM) framework has been developed to address this need. As shown in Figure 1, the framework is represented as a pyramid composed of five layers, or domains:

1. **Business Base:** This is the foundation domain. It covers the firm's overall market understanding (including customers and competitors), its corporate business goals, its strategic imperatives, the dynamics of its business models, and its innovation strategies.
2. **Resources:** This domain covers the people within the company, the corporate facilities, infrastructure and tools, the technology platforms on which products and services are built, and the business partnerships and networks for external collaboration for taking full advantage of open-innovation opportunities (tinyurl.com/2ow32e).
3. **Will and Culture:** This domain addresses the leadership of the company, its governance, its organization, and its culture. As such, this domain represents the heart of the innovation complex, for without will, leadership, an appropriate structure, and a dynamic culture, not much new value will be created.
4. **Solutions:** This domain captures the "creations" of the company: the processes it uses and the products and services it sells. The managing of innovation is in itself one of the critical corporate processes because it encompasses most aspects of the firm, it is critical to the competitive evolution of the firm, and it requires special management attention.
5. **Value:** This domain sits at the pinnacle of the pyramid. It consists of the portfolio of corporate innovation outcomes: its financial outcomes, its customer base, its brand, its territorial position in the market, its social achievements, and its environmental impacts.

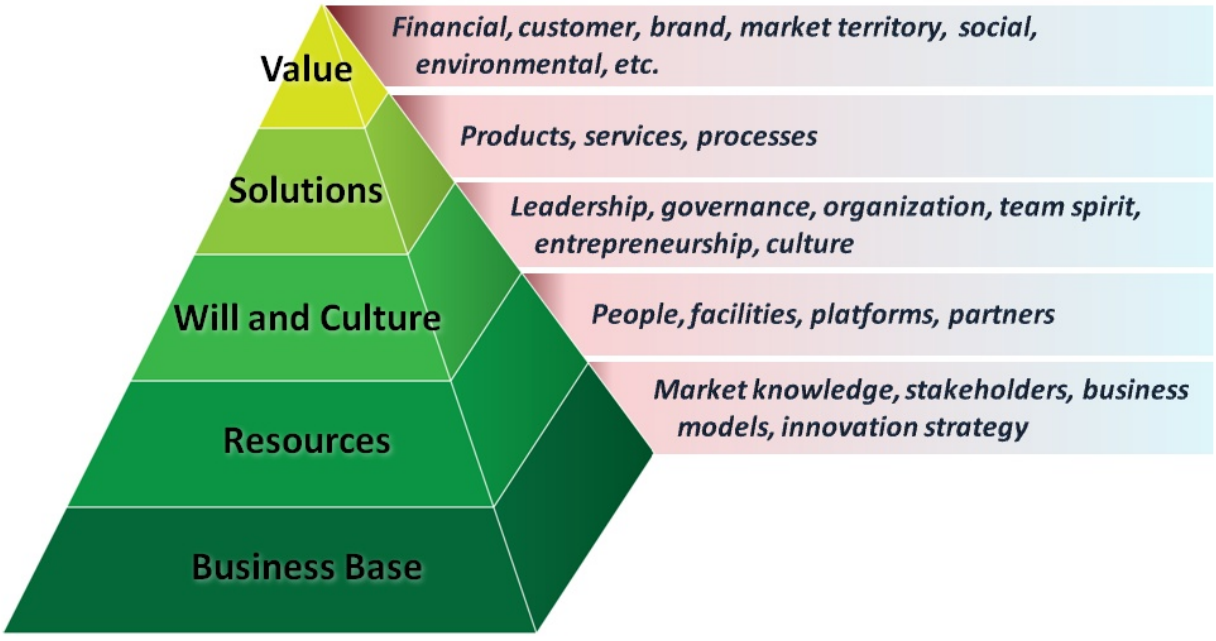

Figure 1. The five domains of the v-CIM framework

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

The v-CIM framework allows full correlation of innovation management with the firm's strategies. It enables an analysis of past performance as well as preparations (capabilities) for future achievements. The v-CIM framework has the benefit of directly capturing a multiplicity of time perspectives – historical, present and forward looking – by enabling the viewing and measurement of the real-time management of innovation processes together with the capabilities for further innovation.

In practice, the use of the v-CIM framework and its associated innovation metrics needs to be done according to the particular corporate perspective, such as a specific functional division/department within a corporation, a single product/service business firm, a multi-product/service business company. These entities can apply the v-CIM framework to each of their product lines and to the company overall, a more complex multi-business unit corporation within same sector, and the very complex multi-sector conglomerate, which requires a waterfall analysis of each of the conglomerate companies.

In all cases, the v-CIM framework enables the targeted selection of a balanced portfolio of indicators and associated metrics for effective measurement-based management of innovation in the company.

Vision and Reality: Intelligent Targeted Competitiveness Assessment

Competitive innovation management reflects an unrelenting drive towards achieving a firm's business goals. A company's management goals may be classified into three acceptable categories:

1. **Managed-to-Sell (MtS):** in general, this is a company building valuable intellectual property (IP) that leads to its acquisition by another company for the sake of access to the IP (and people), or simply to deny their own competitors access to that IP.

2. **Managed-to-Endure (MtE):** a company providing perennial (long term) financial rewards to its founders and investors.

3. **Managed-to-Lead (MtL):** a company managed to capture dominant revenue share in its addressed market segment and to provide outstanding perennial financial rewards to its founders and investors over a very long term.

Enhancing a company's position in its target markets is done through innovation directed at the areas of weakness vis-à-vis key competitors while taking advantage of competitive strengths. A realistic understanding of the business circumstances in which a company operates must be detailed enough to enable its leadership to make the necessary decisions and to pursue operative actions at any moment, as imposed by market dynamics and competitive threats or opportunities.

The objective for the author's development of the Intelligent Targeted Competitiveness Assessment (i-TCA) tool was to create a framework and the means for undertaking consistent and comparative analyses of a company's status and its evolutionary progress relative to primary competitors in its targeted markets. It was meant to be a *monitoring* tool, enabling corporate leaders to capture how the company perceives itself and to assess how well it is progressing on its plan for becoming more competitive. The i-TCA is also a *retrospective* tool, acting as a mirror that tells the company where it is weak and where it is strong. As well, it is a *prospective* tool, telling the company where it needs to innovate to achieve its goals. Finally, it is a *team-building* tool enabling and empowering the corporate management to active participation in strategic planning and innovation management.

The i-TCA software tool was designed in accordance with the v-CIM framework using FluidWare (fluidware.com) online survey technologies. A CEO can achieve a quick, personal subjective assessment of the competitive situation in less than 20 minutes because most of the questions are framed with multiple-choice responses. More value can be achieved by using this software tool with the entire executive team because it uncovers divergences of opinions, enables the resolution of such divergences, and leads to a balanced, collective view of the situation and to a plan to address it.

The basic i-TCA tool consists of five sections, defined as sets of survey questions:

1. **Company Background:** elicits information about the company's business goals and its industry sector, size, age, location, and financial performance

2. **Market Background:** collects information on the size, locations, and competitive situations of primary and secondary targeted markets, as well as the origin of the primary competitors within them

3. **Competitive Attributes:** captures the key competitive attributes that define the culture of the company

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

4. **Collaboration:** collects information on the company's use of external partners in a variety of domains

5. **Competitive Assessment:** contrasts the company's position against its targeted competitor across five domains that consist of 30 areas of competitive differentiation (listed below)

The competitiveness assessment can be done against the primary or secondary competitor in the primary market. Of course, the analysis could also target primary and secondary competitors in the secondary target market, and so on, thus enabling the management to take appropriately targeted decisions against its competitors.

In all cases, the i-TCA tool provides an at-a-glance competitiveness-assessment dashboard that is built as a radial map, which allows direct visual analytics. Each radius on the circular map in Figure 2 represents an area of competitive assessment, with zero competitive performance at the centre and 100% competitive leadership (domination) on the outside circle.

The areas of competitive assessment are grouped into five categories, which, in the basic i-TCA version contain the following parameters:

1. **Business Position:** business partners, brand, revenues, financial strength, channel quality, channel coverage, and government commercialization support

2. **Market Knowledge:** perception by market, frequency of marketing, quality of marketing, competitor knowledge, and market understanding

3. **Corporate Culture:** leadership, governance board, corporate processes, management of human resources, innovation management, and culture of innovation

4. **Technology and Production:** technology advancement, IP protection, speed of development, development affordability, production, and government technology support

5. **Products and Services:** suppliers, customer service, ease of use, performance, functionality, and affordability

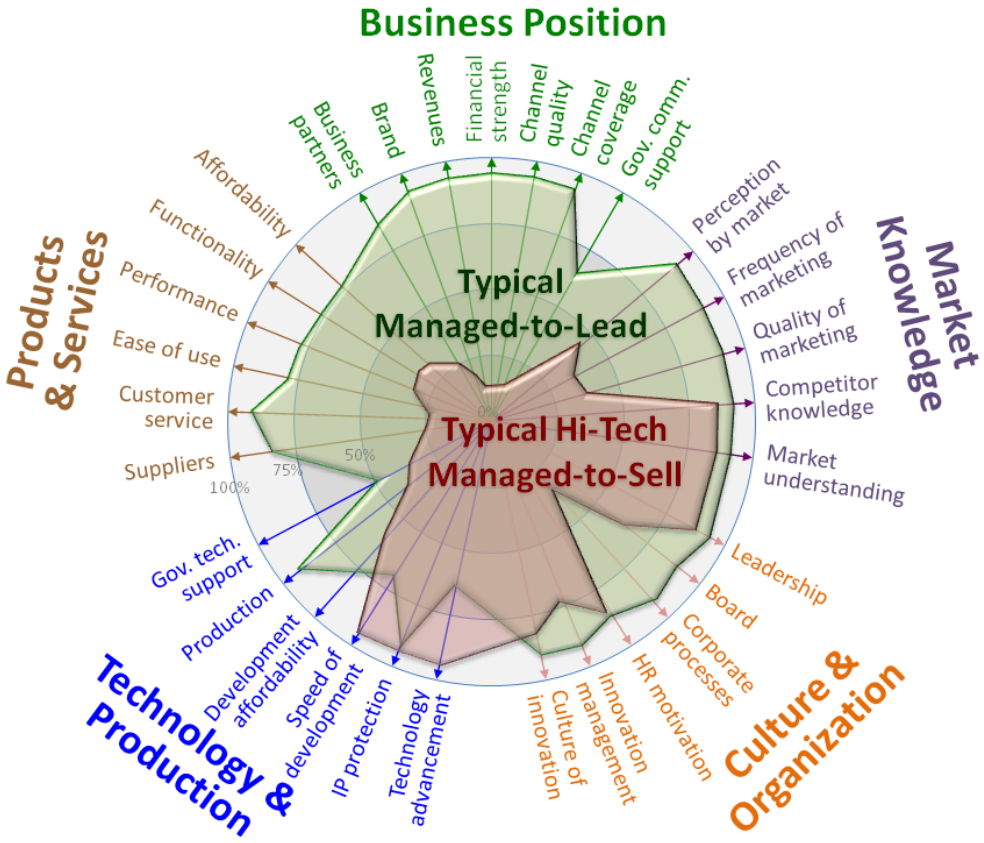

Figure 2. The competitiveness assessment dashboard

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

To guide the user, the background of the *competitiveness-assessment dashboard* also contains representative maps of typical MtS and MtL companies. Rarely is a company leading in all areas, but a typical MtL company (green) is close to the 100% performance circle in most areas. Leading competitors do not always have the best technologies or products, but they do offer the most *appreciated solutions* to their customers. In general, sustainably leading companies focus on their customers, while ensuring they have solid engineering, efficient operations, highly effective sales and marketing, and a strong culture of innovation. In contrast, a typical hi-tech MtS company (red) does not need to exhaust itself in areas that are not essential to its business goal – a quick and profitable sale of the company itself. For technology companies, this goal requires focus on technology excellence and the appropriate marketing of the company to potential acquirers while keeping an eye on threatening competitors. MtE companies usually fall in between MtL and MtS companies.

Beyond the individual use of the i-TCA tool by a company CEO, the methodology for use of the tool by a corporate *team* has four distinct phases:

1. **Team Assessment Setup:** This phase is initiated by a company's leader (the "client") decision to proceed with an intelligent competitive-assessment exercise. Clear objectives are established and the prime responsibilities for the assessment are determined. Next, initial instruction is given to the team, either by webinar or, preferably, in a face-to-face session. A full audio-visual presentation is available for dissemination from the author and its partners, but experience shows that live presentations and subsequent team discussions lead to better results by dispelling some participants' concerns. Also, there is better engagement following such live-team sessions. Once the decision is made, this phase may be as short as a few hours, with the timing largely dependent on the leadership ability to engage the necessary participants in the assessment.

2. **Data Collection:** In this phase, the online survey is made available to each team member. Data collection can be achieved in a day or two if all participants immediately respond online. In practice, it has been found useful to allow for one week and repeatedly call for the completion of the survey.

3. **Analysis and Delivery:** The data is processed using state-of-the-art survey tools and the author's analysis techniques. A report is made available, which includes the competitiveness assessment dashboard and the first-level analysis of the variance between the perspectives of team members. This phase ends with a presentation to the client, with a focus on areas requiring further development.

4. **Follow-up** (optional, if desired by the company's leadership)**:** In this phase, a presentation is made to all assessment participants to engage them in the follow-up processes of corporate development. This phase takes less than a week, with most time spent on discussions with corporate client(s) concerning critical aspects of the assessment.

Overall, the i-TCA assessment process can be as short as a few hours to a few days once the decision to move forward is taken. Data collection and analysis are largely automated in the online survey and subsequent software processing.

Real-Life Examples of i-TCA Competitiveness Assessments

The i-TCA tool was beta-tested in the winter of 2013 with over 80 Canadian executives in small, medium, and large enterprises. The completion rate was quite high with 41 complete answers to the iTCA survey questions. On average, it took an executive 17 minutes to use the i-TCA tool. Some of the results were of high interest to the companies involved and highlighted the value of the tool for competitively managing innovation. To illustrate this value, this section provides an overview of the assessments of three example companies from the beta-test.

Figure 3 shows the assessment results from company A, which appears to be dreaming of leadership although it does not exhibit many of the characteristics of a leader in its market segment. It is very small, with less than $100,000 in revenues after five years, static employment dynamics, and self-declared negative financial performance. Its targeted markets – the United States and Canada – are very large and exhibit fast growth and high-pace dynamics. Company A is very strong in matters of technology advancement, cost of development, suppliers, and product affordability, functionality, and performance. But, it is lacking in all aspects of marketing and commercial positioning in the market. Moreover, its cultural attributes do not describe a company capable of growing to lead in its market segment, especially when it is so brazenly targeting the whole of North America without seeing any direct competitors there.

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

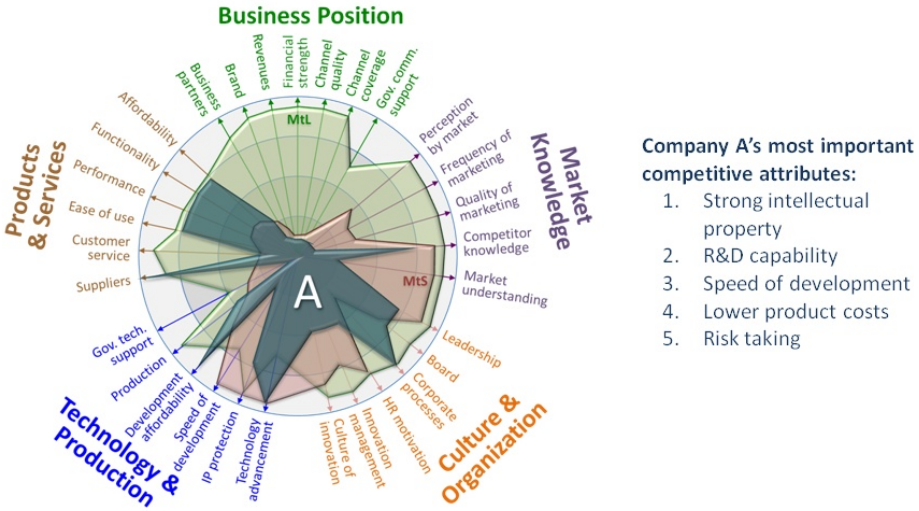

Figure 3. Example A: a company that considers itself "managed to lead"

As described by its i-TCA map, such a company needs a lot of innovation beyond its technology and product if it is serious about *market leadership*. However, the company may be well positioned for a quick sale if it can prove the value of its IP-protected technology and find a suitable acquirer. Thus, company A sees itself as an MtL company, but in practice, its own i-TCA assessment shows that it is performing more like an MtS company.

In contrast, Figure 4 provides the assessment results from company B, a small ICT software company. The company has revenues below $100,000, but it shows some positive financial performance despite it being in existence for less than five years. Its primary markets are USA and Western Europe. These markets are characterized by fast growth and pace of change, but there are few direct competitors, most of which come from the United States. Company B is being managed for a quick sale and appears relatively well positioned to achieve it. As highlighted by its i-TCA map, company B may sell more profitably if it were to apply some innovative actions in matters of marketing, in stronger leadership, and in better protection of intellectual property. Also, it could take advantage of more government support in the technology areas.

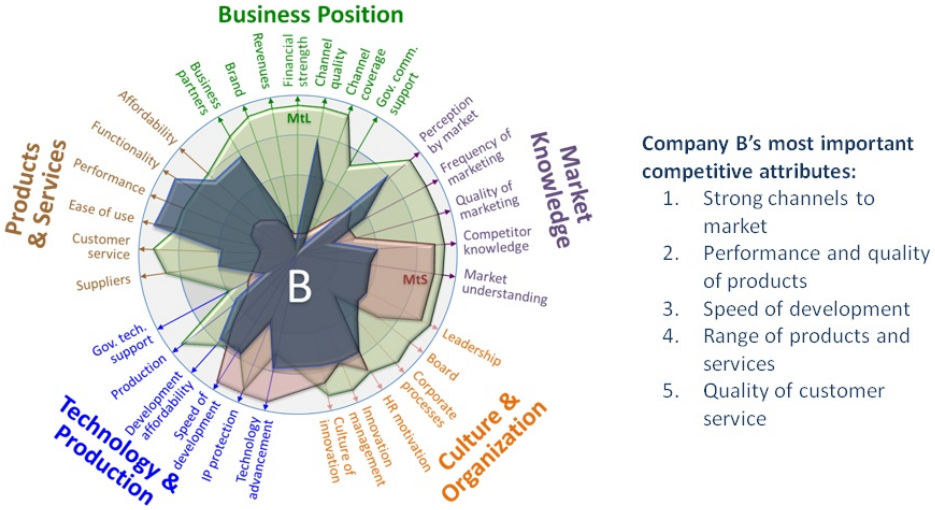

Figure 4. Example B: a company that considers itself "managed to sell"

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

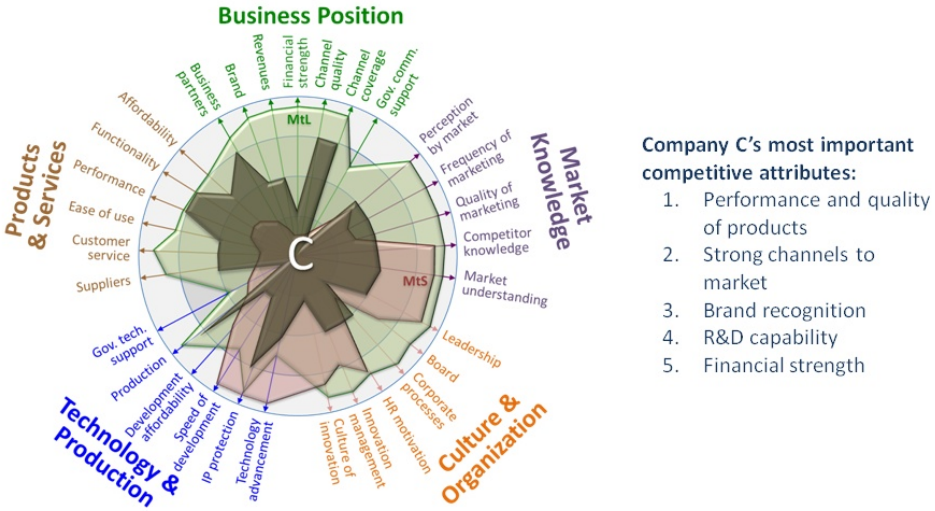

Figure 5. Example C: a large company that considers itself "managed to lead"

Finally, Figure 5 shows the assessment results from company C, which is pursuing a typical “techno-drive” for leadership against global-strength competitors native to the targeted markets of the United States and Western Europe, which are large but with small growth and slow-pace dynamics in the specialized ICT sector of the company. This company is large and mature (i.e., it is over 30 years old and has over 1000 employees), and it has a positive financial performance with annual revenues over $200 million.

As determined by its own i-TCA assessment, company C is far from a leadership position, largely due to its weak board and non-competitive performance concerning development (speed and cost), marketing, customer support, and channels to market – all of which result in poor brand recognition, low revenues, and poor financial strength. It is difficult to think of this company becoming a leader unless it adopts a different innovation strategy and pursues innovations specifically in the areas of evident weakness.

All three of these examples are based on assessments by top-level executives in each company. Still, they are “single-person” assessments and, while instructive, should be followed by full executive-team assessments before undertaking major changes in competitive management and the innovation strategies to be pursued for attaining the corporate goals. Special attention needs to be paid to the company culture because some of the examples above (especially companies A and C) highlight striking levels of misalignment between the company's business goals, its corporate culture, and its innovation strategies.

Conclusion

Industry needs adequate models for the management of innovation activities – models that are capable of tying the various aspects of the innovation domains: products, services, processes, the organization itself, people, and business strategies. The innovation model must enable meaningful, timely, and easy-to-use measurements of performance and capabilities to optimize the use of resources, to adjust the focus of activities, and to ensure that the competitive objectives are achieved.

The v-CIM framework and the i-TCA tool provide both large and small companies with an effective methodology for devising competitive management strategies based on an assessment of their competitive status and by monitoring their progress towards improved market positions. The methodology is straightforward and the tools are easy to apply. The i-TCA tools provide an at-a-glance visual map capable of pinpointing the strengths and weaknesses of a company as perceived by the senior management of the company itself – the people who know best "what is and what is not". Thus, they enable the corporate leadership to act in an informed manner, with judicious innovation strategies and well-targeted activities to bring about tangible results most efficiently.

A Firm-Level Innovation Management Framework and Assessment Tool

Sorin Cohn

By using the i-TCA tool, companies benefit by being able to:

- clarify their vision and business goals in a realistic, competitive context
- map their position on the evolutionary journey to fulfill their business goals
- engage and mobilize corporate leaders and other key players
- enhance the corporate strengths with a consensus on innovation strategies and further developments in accordance with the company's competitive assessment and its vision of its future
- determine a series of actionable plans, with priorities to mobilize resources

The i-TCA tool is being developed for volume commercialization. It will provide several versions enabling basic as well as in-depth, detailed competitiveness assessments vis-à-vis primary and secondary competitors in targeted markets. The beta version and associated consulting services are available from the author and his company, BD *Cohn*sulting.

The i-TCA tool also has value for organizations interested in macro views of the entire national industry and its key constituent sectors. A large-scale competitiveness assessment could establish a database for benchmarking industry sectors to discern areas of sectorial weakness and determine remedial actions.

The criteria by which we measure relevance and success have a profound impact on how we examine, manage, and judge innovation. Moving away from "appreciation in the eye of the beholder" to objective methods for measuring innovation enables the transition from innovation management as an art to being a results-oriented engineering practice.

About the Author

Sorin Cohn has 35 years of international business and technology experience, having been involved in most facets of innovation development: from idea to research and lab prototype, from technology to product, and then to market success on the global stage. He has developed new technologies, created R&D laboratories, started new product lines, and initiated and managed new business units. Sorin has several essential patents in web services, wireless, and digital signal processing, as well as over 70 publications and presentations. He has also been Adjunct Professor at the University of Ottawa. He is a Killam Scholar, and he holds a PhD in Electrical Engineering, an MSc in Physics, and an MEng in Engineering Physics. Sorin is President of BD *Cohn*sulting Inc. As well, he acts as Leader of Innovation Metrics at The Conference Board of Canada and as Chief Program Officer of i-CANADA. He is also Member of the Board of Startup Canada as well as the Board of the Centre for Energy Efficiency.

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Reinventing the Wheel: Contextualizing Existing Innovations as a Path to Market Success

Jeff Moretz, Karthik Sankaranarayanan, and Jennifer Percival

> *"Creativity is not the finding of a thing, but the making something out of it after it is found."*
>
> James Russell Lowell (1819–1891)
> Poet, critic, editor, and diplomat

In the quest to create cutting-edge products, organizations often invest substantial time, attention, and capital in primary research and development (R&D). By themselves, these R&D investments to create avant-garde products may not provide good return-on-investment. In the context of Canadian businesses, there is a significant scarcity of resources available for R&D. What can Canadian firms do to stay innovative when they face a plethora of difficulties, including insufficient funding? This article explores how organizations can leverage external innovation and existing technologies to create products or services that cater to the market needs. We present a three-pillar model along with examples of companies that attained market success in large part by contextualizing existing technologies in order to create innovative products or services. This approach provides companies with a high-level framework to facilitate resource-parsimonious creation of commercializable, innovative products that are competitive in today's global marketplace.

Introduction

One of the truisms regarding innovation is that one should not try to "reinvent the wheel" or "discover how to do something that has already been discovered" (Cambridge Dictionary of American Idioms, 2003; tinyurl.com/n668msr). When business people fail to recognize the value of something "not invented here" or perhaps fail to recognize that an outside innovation exists at all, a great deal of effort can be wasted. However, we argue that broader attention to context is necessary for market success, and that leveraging existing technologies toward the creation of products or services that are attractive to the market can provide a less resource intensive path to successful innovation. Some degree of "reinvention" in order to contextualize an innovation promotes greater value creation across a variety of settings. This means that such reinvention is, in fact, not a rediscovery of something already discovered, but rather an extension of it. A novel combination of existing elements constitutes every bit as much innovation in terms of value creation and market opportunity as the creation of fundamentally new elements.

The notion of a social system within which innovations are situated and communicated implies the need to contextualize innovations for consumption in a given market. A focus on contextualizing innovations that appear elsewhere in order to make them more compatible with changing market demands or expectations – either adding new elements, subtracting others, or combining existing elements in new ways – provides businesses with the opportunity to reap substantial benefits without the need for far-reaching and time-consuming investment to create innovations from whole cloth. The other edge to the sword of focusing on such "reinvention" is that it may reduce the capacity of firms to engage in the kind of ground-breaking innovation that may generate leadership positions in global markets. However, as the experience of BlackBerry (tinyurl.com/bjucast) makes clear, failure to reinvent one's own wheel from time to time in order to address specific market concerns is a path fraught with risks of its own.

However, one of the critical issues facing businesses in general, and Canadian businesses specifically, is the lack of resources for fundamental research and develop-

Contextualizing Existing Innovations as a Path to Market Success

Jeff Moretz, Karthik Sankaranarayanan, and Jennifer Percival

ment spending (Council of Canadian Academies, 2013; tinyurl.com/mnyypck). In addition, firms that expend considerable resources on in-house research and development (R&D) may face difficulty and delays in achieving returns on those investments. They may also fall prey to the "not invented here" syndrome (tinyurl.com/yuwk96). Such issues with a focus on foundational R&D are significant and well known. Yet, when assessing the market prospects of firms, particularly firms in the high-technology sector, a great deal of attention is paid to fundamental innovation activities as represented by spending on R&D (Booz & Company, 2012: tinyurl.com/l9sf76z; Hall and Lerner, 2010: tinyurl.com/mr4hvro), with Canadian investment significantly lagging behind the global field (Conference Board of Canada, 2013; tinyurl.com/mu6b946). The value ascribed to patenting implies that firms that invest extensively in R&D will exhibit superior performance because of their activities in developing new technologies and products for which there is little viable competition and for which they can protect the underlying intellectual property (e.g., Arora et al., 2003; tinyurl.com/ljsqbfx). However, there is evidence that extensive R&D spending does not lead inexorably to superior performance (Boulding and Staelin, 1995; tinyurl.com/llnql53). In fact, high spending on R&D may not even lead to superior innovativeness. Fast Company's annual list of the most innovative companies in 2012 (tinyurl.com/7hk5k4j) includes none of the top R&D spenders listed by Forbes (Hartung, 2012; tinyurl.com/b5qykex). Forbes points out that these high spending R&D companies are not particularly good investments. Faced with such a wide array of difficulties with respect to innovation, what are firms to do? We argue that firms should rebalance their resources by focusing greater effort on tailoring innovations to particular market demands.

Technologically and commercially successful innovation requires a combination of three basic knowledge types: technical expertise, market knowledge, and organizational skill. These three building blocks form a solid foundation for bringing innovations to market successfully and profitably. Technical knowledge is necessary, but mere technical savvy is insufficient to the task of developing a commercially viable product or service. Firms must also possess sufficient understanding of the market to which a particular product or service is to appeal. Such market knowledge allows the packaging of technical capabilities into something that provides sufficient value to a buyer to induce a profitable transaction for the seller. Thus, this knowledge allows firms to address the needs of a target market, facilitating acceptance of the innovative product and diffusion of the innovation (Rogers, 2010; tinyurl.com/ntrq2f6). Yet, the specific combination of elements will depend in part on the firm's underlying set of resources and capabilities (Barney, 1995; tinyurl.com/mcay3sk), which will differ from those of competitors. As Michael Porter (1996; tinyurl.com/pqfuath) argues, companies cannot be all things to all customers, but must make tradeoffs that provide a sustainable strategic position that is different from that of any competitor. Finally, firms must possess sufficient managerial or organizational proficiency to construct, control, and continue the systems that support product development, manufacturing, service delivery, commercialization, and subsequent product development efforts (Wang et al., 2010; tinyurl.com/lbmtnex). We propose that these elements represent the three pillars of commercializable innovation, as depicted in Figure 1.

In this article, we argue that paying greater attention to the requirements of a target market can reduce the need for costly and time-consuming foundational technological development while providing substantial opportunity for successful commercialization. We address each of these aspects of innovation, market-focused development, technical development capacity, and organizational capacity, with reference to real-world innovation examples. The examples include earlier innovation efforts that leveraged the approach discussed in the article as well as ventures that have chosen this approach more recently.

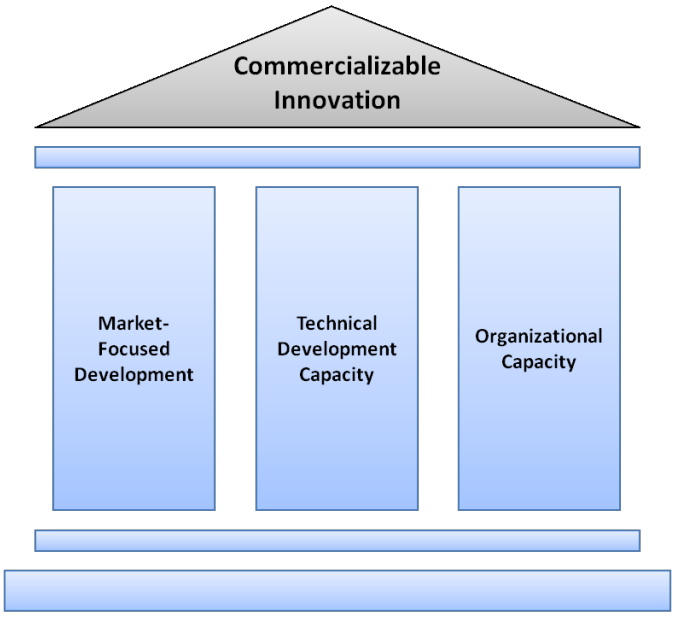

Figure 1. Pillars of innovation value

Contextualizing Existing Innovations as a Path to Market Success

Jeff Moretz, Karthik Sankaranarayanan, and Jennifer Percival

Market-Focused Development

Although sufficient technical capacity to create a functional product or service system is a prerequisite for developing substantially new products or services, there is a significant market element in the success of any innovation in terms of firm performance. In order to profit from investment in innovation, a firm must create innovative products or services that provide sufficient and recognizable value for some set of buyers. There has been a great deal of disagreement regarding measures of product development (Griffin and Page, 1996; tinyurl.com/kq2ctxv); however, the metrics used in engineering – in which quality is assessed in terms of the degree to which the final output meets the specifications set for the development project – are not particularly useful measures for successful product development at the firm level. This engineering approach to measuring quality captures the capability of meeting design goals, yet it ignores the possibility that management may misapprehend the actual desires of the market, and thus may successfully produce a "high quality" product with limited potential for market success. Attention to marketing in addition to technical development efforts has the potential to dramatically increase the adoption and value-creation possibilities of new products (Dutta et al., 1999; tinyurl.com/n2ov39s).

Market success requires the combination of multiple elements into a package that creates greater perceived value for buyers than competing offerings (Yang and Kang, 2008; tinyurl.com/lsg9exx). Highly innovative companies, such as number 1 on the Fast Company list (2012; tinyurl.com/7hk5k4j), Apple, create highly valued offerings that combine numerous technologies. Many of the technologies in the iPhone and iPad were developed from the ground up in Apple facilities. However, Apple has also leveraged outside innovation since the 1970s. As Malcolm Gladwell points out in his article "Creation Myth" (2011; tinyurl.com/3fmz4ee), many of the technologies employed in the creation of Apple's first gangbuster market success, the Macintosh, were first developed by Xerox Corporation at the legendary Palo Alto Research Center (PARC; parc.com). PARC researchers had developed the graphical user interface (GUI), the computer mouse, the WYSIWYG text editor, and the first iterations of Ethernet. However, despite this panoply of technologies that, in retrospect, are obvious to us all as sources of tremendous value, Xerox failed to achieve significant market success with any of them. The success of Apple was a combination of product development and market savvy. Jobs and company took the kernel of the ideas produced at Xerox PARC and developed a functional system that provided exceptional customer value by fundamentally altering the way people interacted with computers. However, this transformation was not instantaneous, cheap, or even obvious (except in hindsight). Apple first developed the Apple Lisa, a radically overpriced and under-capable machine that was a colossal market failure. Only through extensive subsequent development was the company able to create the market success that was Macintosh.

Technical Development Capacity

Of course, all of the marketing capability in the world will generate little profit without sufficiently functional technical elements. McDonald's possesses one of the world's most valuable brands (Interbrand, 2012; tinyurl.com/9v2haam), but it is the service delivery technology – primarily McDonald's highly developed food service processes – that create the consistency and reliability upon which the brand rests. In the high-technology domain, technical development capacity is critical for producing a product that has the capabilities that a firm can market to customers. Such technological know-how is generally expensive to maintain, but it is a cost of doing business in the high-technology sphere. However, firms need not maintain exceptionally high expenditures on ground-breaking fundamental research in order to possess sufficient technical development capacity to produce eminently saleable products.

The example of the feedback between Apple and Xerox PARC helps to make this point clear. In the development of the computer mouse, Xerox PARC researchers began the development of the idea created by a Stanford researcher, and the engineers at Apple evolved it still further into a simple product that integrated well with a simplified computer operating environment with dramatically more intuitive controls that facilitated work that people wanted to accomplish (Gladwell, 2011; tinyurl.com/3fmz4ee).

The fact that Xerox PARC was located where it was, rather than close to the east coast headquarters of Xerox Corporation, was no accident. The PARC was one player among many in the Silicon Valley cluster of high-technology development. By positioning research centres in the same geographical area, firms were able to leverage significant concentrations of knowledge and supporting services that would have been difficult to ac-

Contextualizing Existing Innovations as a Path to Market Success

Jeff Moretz, Karthik Sankaranarayanan, and Jennifer Percival

cess elsewhere. The firms in Silicon Valley also leveraged proximity to world-class research universities. Stanford University and the University of California, Berkeley provided access to cutting-edge research insights without the need for funding wide-ranging and expensive basic research.

Another significant entrepreneurial innovation success traces its roots to similar colocation. Research In Motion, now BlackBerry (tinyurl.com/y5c86x), is headquartered in the Kitchener-Waterloo area that is home to myriad technology companies. This colocation provides a critical mass of science and engineering talent, support services and capabilities, and technologically savvy collaborators, colleagues, and competitors with whom science and engineering staff can exchange thoughts and ideas. The proximity to the University of Waterloo and its engineering and technology capabilities is no accident. Research in Motion hired hundreds of Waterloo graduates over the years to assist with product development efforts.

Similar to the example of Apple, Research In Motion (now BlackBerry) did not invent most of the foundational technologies that it utilized. The Mobitex network standard (tinyurl.com/5b69t7) for packet-switched wireless data transmission was developed in Scandinavia by a joint venture between Ericsson and Televerket, the Swedish telecommunications agency. Research in Motion engineers eventually developed a method for sending and receiving messages, leading to the creation of two-way wireless communication devices and, a few years later, the first BlackBerry device. By leveraging existing technology that facilitated secure and reliable communications, Research In Motion was able to create a dominant market presence in business communications where such security and reliability were highly prized. However, it was not the underlying technology that created Research In Motion's success, but rather the combination of technological knowledge and market knowledge, along with the organizational capacity to bring the resulting product to market.

A more recent startup in Toronto is using a similar approach to developing a service offering. Syngrafii (syngrafii.com) leverages the LongPen technology developed for Margaret Atwood (tinyurl.com/ywwzlc). Atwood invented the LongPen in order to enable remote book-signing events. The complete solution that Atwood conceived allows audio and video transmission in addition to a pen and ink remote signature that is an exact duplicate of the signature produced by the signer. The conception of this technology is quintessentially Canadian, inspired by the vast landscape across which Canadians seek to communicate and collaborate.

The commercialization approach taken by Syngrafii is to convert this foundational technology into solutions for remote signing of legal documents. The service has the advantages of remote signatures while avoiding the necessity of radically altering existing business processes that are based upon physical signatures. Although the advantages to such an approach may seem obvious, Syngrafii has undertaken additional development in order to make the technology viable for legal documents. The foundational technology is fully functional for remote book signings in which participants are generally satisfied with the synchronous video-conferencing as a guarantee of the legitimacy of the signature; however, it requires additional development to meet the requirements for verifiable legal signatures. Yet, by starting with a technology that has proven capability to meet a critical subset of the task requirements, Syngrafii is far ahead of the game in developing a remote-signature solution that produces physical signatures (as opposed to purely digital signatures, which are far less appealing to potential customers such as banks because they diverge so radically from the signatures for which legal precedents exist).

Syngrafii is thus utilizing a prior technological development in order to move into a new market space by redefining what that technological development can do. Such reconceptualization of existing technology requires additional technical work, and it certainly requires additional adaptation to fit a specific target market's needs, but it is a much less fraught and less-time consuming approach to developing innovative offerings.

Organizational Capacity

The combination of functional technological elements with viable market positioning and compelling customer value is accomplished through the marshalling of a vast array of resources, capabilities, and connections. The creation of innovative technology alone is insufficient. A firm must also possess a culture that values innovation, is capable of assimilating innovations, and can turn new developments into viable market offerings (Wang et al., 2010; tinyurl.com/lbmtnex). An attractive market position without capable product or service technology is a recipe for long-term disaster, though the persistence of vaporware, products that are an-

Contextualizing Existing Innovations as a Path to Market Success

Jeff Moretz, Karthik Sankaranarayanan, and Jennifer Percival

nounced but never produced, argues that there may be some short-term advantage to staking out mindshare in the market even absent a viable technological solution. It is the combination of an array of complementary resources and capabilities that creates real and lasting value in the marketplace and the exchange. Firms that lack this capability of organizing and managing the interconnections between the elements of a market offering suffer reduction in profitability or market share or reputation/brand image. Organizational capacity is the glue that binds all of the firm's capabilities into a coherent system that can deliver customer value.

Over the long haul, persistent lack of organizational capacity results in a loss of brand reputation, market share, and profitability. Apple suffered just such an attrition of market position in the 1990s as the appeal of its products diminished, the brand name slid in public perception, and corporate results were so poor that many market watchers expected bankruptcy. Some even went so far as to call Apple "arguably one of the worst-managed companies in the industry" (Intelligent Speculator, 2011; tinyurl.com/pol23qr). Similar speculation has been made regarding the prospects of BlackBerry (the new name taken by Research In Motion after its recent near-death experiences). Both companies suffered a failure of management that led to ineffective use of the technical and marketing capacities they had developed. Apple navigated its organizational crisis to emerge as a market leader in the commercialization of technology, though it still ranks well down the list of big spenders on R&D relative to size. One of the chief components of Apple's success has been the creation of effective mechanisms for capitalizing on the creations of others in order to provide customer value. The success of Apple's flagship products relies as much on iTunes and the App Store as it does on Apple's product innovations. BlackBerry might manage a similar renovation to reestablish itself as an innovation leader, but doing so would require radical improvement of the overarching organizational capacity necessary for pulling myriad disparate pieces of technological and market knowledge together into an attractive and saleable package.

Conclusion

The constraints faced by many businesses in terms of resources available for fundamental research and development are well known. However, these constraints need not be prohibitive of innovation success. The model proposed in this paper addresses the difficulties faced by innovating businesses, particularly innovators operating in environments with modest R&D resources, by highlighting the value of identifying and exploiting market opportunities that leverage existing technologies and packaging them into commercializable product or service innovations. Firms that seek commercialization opportunities utilizing existing technologies can achieve substantial success in the marketplace.

In order to capitalize on technological innovation, firms must have sufficient capabilities in three core areas: technical development, market knowledge, and organizational capacity. Technical development capabilities are necessary in order to turn any single technology into a saleable product or service. Reconfiguration allows firms to start farther along the technical development curve, but it does not eliminate the need for technical capabilities. By reconfiguring existing technologies, firms reduce the need for R&D spending on foundational technology. Although this approach might seem to limit the degree of intellectual property protection a firm could leverage, the examples above show that such concerns need not be prohibitive. Market knowledge is critical for turning any technology into an offering that is attractive to a focal market. Firms that neglect market knowledge are likely to find their ability to profit from their technologies to be significantly constrained. Finally, firms must also develop sufficient organizational capacity to combine the technical capabilities and market knowledge into a saleable offering that instills confidence in buyers regarding quality and reliability. Thus, technical development capabilities are necessary, but extensive emphasis on fundamental research is not necessarily the most reliable path to market success. Although the specific approaches to divining the needs of various markets are manifold, many firms will find it advantageous to pay greater attention to knowledge of particular markets and their various needs and expectations. This approach can provide significant opportunities to leverage existing technologies to create value for customers and profits for those firms that reinvent the wheel, by packaging innovative components effectively.

Recommended Reading

- Booz & Company: Global Innovation 1000 (2012; tinyurl.com/96rqmmt)
- McKinsey Global Institute: "Disruptive Technologies" (2013; tinyurl.com/nmbecug)

Contextualizing Existing Innovations as a Path to Market Success

Jeff Moretz, Karthik Sankaranarayanan, and Jennifer Percival

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Corporate Lifecycles: Modelling the Dynamics of Innovation and Its Support Infrastructure

Tamas Koplyay, Lisa Chillingworth, and Brian Mitchell

> *"Concentrate your energies, your thoughts, and your capital. The wise man puts all his eggs in one basket and watches the basket."*
>
> Andrew Carnegie
> Business magnate and philanthropist

Corporate leadership and corporate culture have to be aligned to market realities to ensure the long-term success of a firm. As companies form, grow, and mature, the management of the enterprises also have to evolve through the business lifecycle. What is successful in the introduction stage may not be successful for a mature company. Firms are required to change their focus from product development, to market development, to process development, and finally to market and financial leadership. To be successful means that not only the types of employees hired have to evolve to support the culture required, but the leadership styles and management focus also have to change and adapt to the new realities that firms encounter in their market. The dynamic model presented in this article shows the broad strategic imperatives that must be met by firms, and it is presented through a graphical illustration of how successful firms manage their evolution and how firms can fail through mis-allocation of corporate efforts to non-mission critical initiatives.

Introduction

Although the effects of leadership and culture on innovation are well known, and various factors that influence innovation have been examined extensively in literature, a consistent model explaining the relationships between leadership, culture, and innovation is lacking. Additionally, the characteristics of the evolutionary change throughout the corporate lifecycle and the constituent individual phases delivering the innovation are poorly understood.

At the core of this article is a model that incorporates the effect of leadership and organizational culture upon the evolution of innovation during the firm's market lifecycle. The model is predictive and explanatory, and it incorporates the changing profiles of culture and leadership as well as some critical staffing issues. The article presents the foundational aspects of the model that treats the factors as a dynamic ensemble and aligns culture, leadership, and corporate function with the type of innovation being pursued. The organizing framework of the market lifecycle is the foundation upon which this model is built, but the concurrent phenomena of product and the firm lifecycles will also be considered.

The ideas presented in this article are the culmination of the primary's author's 20 years of experience teaching, consulting, and acting in director-level research roles in the high-technology industry. Many of these concepts are derived from the lifecycle theory extended by the author and have been tested in over 200 case studies, industry surveys, and consulting assignments.

The Dynamic Duo: Culture and Leadership

Like people, organizations develop and live within a culture and respond to specific leadership. However, as opposed to the individual, organizations pass through

Corporate Lifecycles: Modelling the Dynamics of Innovation and Its Support Infrastructure

Tamas Koplyay, Lisa Chillingworth, and Brian Mitchell

several stages of development of culture and experience different leadership styles depending upon where they are in their own product, market, and firm-maturity lifecycles.

A startup generally is led by a focused entrepreneur who, through almost messianic leadership, focuses the firm on the potential of the future and can be nimble in management decisions and changes in strategic direction. With the focus on potential success, creativity and innovation are generally nurtured and promoted during the initial stages of the technology lifecycle (tinyurl.com/6cog6u). Should the firm enjoy the market's early adopters becoming their clients, the firm can focus on attracting the early and late majorities of the market customers. Moore's (2005; tinyurl.com/lzstrav) work on market cycles can be used to show that once the early majority is engaged, the firm has moved from an introductory stage to a stage that is characterized by growth. Through the introduction and early growth stages, management of the firm is dynamic and fluid. Trial and error can create small failures that evolve into long successes over time.

However, in the case of market entry by firms whose cultures are not aligned with the early market, problems can ensue. As cultures supersede each other along the lifecycle, as will be later explored in this article, product creativity becomes progressively restrained and even stifled within the firm, and the competitive edge for young markets is effectively lost for the marginal and incremental innovation that accompanies a mature or declining market. The entanglement gets even worse when the three cycles of product, firm, and market interact.

An example of a culture clash between market lifecycle position and management is highlighted in the following example from the Canadian high-technology industry. A mature firm may try to enter a startup market with growth products by spinning off a division or a wholly-owned company, as was the case with Entrust (entrust.com), a pure startup in internet security. In 1994, Entrust was born of Nortel (tinyurl.com/24gm7a), a mature telecommunications networking company, and was competing with products that perhaps were more suitable for a growth market than the startup situation. There was a triple incompatibility between: i) the firm's startup culture, ii) its large parent's culture, and iii) its products, which it intended to bring to market as complements to other firms' products. This triple incompatibility of market, firm-management culture, and product lifecycles leads to a strategic gap that can be impossible to manage. Only once free of the parental embrace, was Entrust able to quickly adjust its strategic focus to create long-term market traction, and it continues to be relatively successful at the time of writing this article in 2013.

As a further example of such a management challenge, consider a company that competes with a product portfolio that ranges from startup to mature, and offers these products through affiliates into markets of differing stages of development, hence of different cultural profiles. Such was the case with another Canadian high-technology company, Newbridge Networks (tinyurl.com/lma83fl). At its maturing stage, several young startups controlled by Newbridge pursued their own market ambitions and were barely linked to the parent through minimal ties of administrative and financial support. The reason for this was primarily to prevent the submerging and capture of the young firms' cultures by the dominant, mature culture of the parent. The young firms remained in orbit around the parent but never came close enough to be captured by the inexorable gravitational pull of the parent's culture. Similarly, when Research In Motion (now BlackBerry: blackberry.com) acquired QNX (qnx.com), a strategic distance was maintained to allow QNX to breathe in its own rarified entrepreneurial atmosphere. Such efforts underscore the importance of keeping a young culture at an arm's length from a mature one, because the mature culture eventually contaminates and destroys the inherent creativity of the younger firm. There is a hierarchy of dominance, especially in the high-technology sector, where maturity dominates growth and growth dominates startups.

How does a startup culture transform into a growth culture and why? The rules of the game change markedly when, and if, the bridge is crossed from early market to mass market, especially with high growth. Management now has to deal with early majority customers and selecting the correct target customers. Additionally, customers become more price conscious, thereby driving margins downward. Product feature development give way to reliability and compatibility concerns. During this time, the leadership and culture have to adjust from free-form innovation to more risk aversion and customer focus. Developers give way to functional managers, and the entrepreneur gives way to professional managers. Part of this process can also be explained by the needs of the venture capital investors who are looking for returns at the earliest time. Sales

Corporate Lifecycles: Modelling the Dynamics of Innovation and Its Support Infrastructure

Tamas Koplyay, Lisa Chillingworth, and Brian Mitchell

and distribution channels now matter as much as the product itself, and management adjusts again to a different frame of perception. The growth firm expansion can move toward the lean manufacturing model popularized in Japan where innovation is incremental (Koplyay et al., 2009; tinyurl.com/k98wndr) and not able to deal with sudden market or technological changes such as disruptive technologies (Christensen, 1997; tinyurl.com/7onvohk).

Once the high-growth period levels off and maturity is reached, the firm becomes more entrenched in the professional management of internal resources, profit margins, and distribution channels in order to make efficient production and sales choices. At this early maturity stage, the firm invests in both soft infrastructure (e.g., marketing channels, supply chain management, and training programs) and hard infrastructure (e.g., technology and production capacity, if not outsourced). The investments are focused on maintaining or increasing market share. Much of the managing is now focused on protecting the shareholder's equity and building or maintaining the stock price, or maximizing private ownership's return on investment. The customer base now contains the late majority, where customer skepticism, product functionality, and price-motivated consumer behaviour drive the firm's management decisions. Price leadership, thus commoditizing the outputs and creating local price inelasticities through minimal product differentiation within the market space, is the focus of management. Production efficiencies become critical in a commoditized and competitive market (Kim and Mauborgne, 2005; tinyurl.com/l7g2kzg) and market share is either won through price leadership or growth through mergers and acquisitions. These approaches dominate strategic thinking in order to create better economies of scale and underpin a successful cost-leadership strategy in a price-taker market.

To accommodate this new reality, the culture/leadership scene transforms again with a mature, top-down approach with much formalized structures through rules, regulations, and policies, all of which are reinforced through training and careful cultivation of corporate culture benchmarks. The mature market is fairly predictable, both in terms of customer conduct and competitor behaviour, so much so that planning can become routine if somewhat circumspect and data rich, and some of the surprise moves of the occasional cunning competitor can be discerned through competitive intelligence. So, if the market lacks true dynamics, and everyone is running with the same cost-leadership strategy then it is inside the firm that competitive advantage must be gained. And, in fact, that is exactly what happens: the emphasis is on strategy implementation and not choice, unless a firm such as Apple decides to create a niche market and then later reinvades the mass market from this market niche refuge. As the market ossifies, so does the specific firm culture, and it becomes entirely devoid of bold imagination and obsessively focuses on production, incremental innovation, cash flow management, and efficiency. There is one more potential transition from a quality culture to a production culture, where discipline becomes the operating maxim, the timing of market exit becomes critical, and redeployment of cash flows dominate.

Culture and Leadership Follows Lifecycle

The organizational lifecycle, as defined by Rowe and colleagues (1993; tinyurl.com/l29nhee), divides the firm's evolution into four stages: Introduction, Growth, Maturity, and Decline. In each stage, a different type of leadership and organizational culture is required for success. During the Introduction stage, the leadership style is generally inspirational with a creative organizational culture. Growth requires both supportive leadership and organizational culture as the firm begins to develop its unique culture and organizational standards. During this time, transformational leadership of "motivation, empowerment, and morality" is required, as defined by Gill (2011; tinyurl.com/ldmg8aa). As the firm moves into Maturity, the dynamics change: leadership becomes more logical and formal, the culture moves towards a quality focus and becomes incremental concerning innovation. During the Decline stage, the production and cost-focused culture is driven by a directive and oftentimes remote leadership style. Notwithstanding Gill's assertion that transformational leadership should be pursued throughout the life cycle, the latter two stages tend to evolve into transactional management/leadership and generally are based upon the reward/penalty power of management.

It is important to note that a precise match must remain between culture and its corresponding leadership. At the turn of the century, Ford Motor Company ran into a major crisis, when its leader, Jacques Nasser, insisted on rejuvenating its culture by shifting focus from their core competency of automobile design and manufacturing to a broadly-based conglomerate by acquiring automobile junk yards and auto repair shops in Europe (Rothschild et al., 2004; tinyurl.com/kqroqtc), and providing a personal computer for most employees (Langer, 2003; tinyurl.com/ltxmov5). This effort to instill

Corporate Lifecycles: Modelling the Dynamics of Innovation and Its Support Infrastructure

Tamas Koplyay, Lisa Chillingworth, and Brian Mitchell

more creativity through the disruption of existing routines caused immense confusion, resulting in collapsing operating and financial fortunes and led to the hasty departure of Nasser from Ford. On the other hand, transformational leadership at IBM by the CEO Lou Gerstner became a spectacular success. The transformation at IBM was done in a very different way than Nasser's attempt at changing Ford's corporate culture. Gerstner first parceled out the company into independent units and then endowed each with its own appropriate culture and leadership depending on the markets served (Gerstner, 2003; tinyurl.com/kzogngf). There was no cultural overlap or dissonance as there was at Ford. In light of these examples, several important points should be made about the dynamics of culture and leadership. First, culture is path-dependent. How you get there matters, whether culture arises naturally and was nurtured, as is commonly the case in startups, or is imposed by necessity, as in IBM. A young culture has no antecedent and forms largely due to the staffing policies of the firm, by the hiring of young, ambitious, and dream-fuelled product developers who have the same background and temperament. This condition reinforces the young culture because it prevents the formation of silos, and the culture is easily diffused throughout the organization and maintained within it. Furthermore, incentives, such as stock options, create a natural driver that propels everyone in the same direction for the young culture to strive to build firm success that they will benefit from once the firm transitions from startup to growth.

Mature company cultures have a lot of stability with formal structures and defined hierarchies, whereas startup cultures are fragile: remove the messianic entrepreneurial leader and stock options, and introduce diversity of individual backgrounds into hiring, and this culture will disintegrate fairly quickly. Normally, when leadership and culture are in conflict, it is leadership that loses, as in the case of Jacques Nasser at Ford. The exception of IBM represented a conscious effort to destroy and rebuild the culture by a secure and determined leader who was ready to risk the future of the firm by doing several cultural reversals and transplants.

Staffing Influences Culture and Follows Lifecycle

Concurrent with the transitions of culture and leadership within the firm travelling through the corporate lifecycle, staffing challenges follow suit and succeed in orderly fashion to match the evolutionary changes. Again, incompatibility can lead to either sub-optimal performance, dysfunction, or long-term employee dissatisfaction. In young cultures, we find self-motivating, risk-taking, and team-oriented players who totally invest their efforts in the long-term success of the firm. As culture progresses to the Growth stage, where more formal structures tend to become risk averse, the risk taking is washed out and teams become silo-prone functional groups, and compensation focuses more on individual performance than the collective results. This change occurs largely because tasks are much better defined in the mature firm and are narrower in scope, and hence compensation can be tailored to the task or responsibilities at hand. But, there are obvious drawbacks given that the commonality of purpose may be lost. Workers, whose job is to produce a set product in a lean manufacturing environment, will continue to do so until they are told to change; their positions do not allow them to know or understand the corporate strategy and the efficacy of such strategy. Workers on the production floor have their performance measured in short timespans, whereas the performance of the senior executives are measured in a time horizon of months or years depending on the marketing and production cycles of the firm. Dysfunction can creep into the firm as employees producing the product are performing their jobs in a stellar fashion, yet the product itself is not being purchased by consumers; thus, the production staff are not contributing to the ultimate success of the firm, no matter the quality of their efforts.

As the firm evolves through the lifecycle, the actual types of people employed by the firm can also impact the success of the firm. As with management, the fit of the employee grouping can have a positive or negative impact on the firm's productivity and profitability. During the Introduction stage, small startup companies tend to "make do" with the resources they have; generalists are in high demand. Those who are willing to take risks and able to react to sudden changes are generally also those who are willing to forego high wages by building stock ownership as a form of compensation. As the firm enters Growth, the types of employees become more risk averse and fit into functional groupings with increased organizational discipline. As Maturity is reached, the formal structure of the firm requires employees who have highly differentiated roles and responsibilities, fit into the established corporate routines, and can be nominally proactive. Decline tends to exhibit a highly regimented structure with employees focused on the process and cost containment, a high degree of labour specialization, and risk aversion as an individual and corporate trait.

Corporate Lifecycles: Modelling the Dynamics of Innovation and Its Support Infrastructure

Tamas Koplyay, Lisa Chillingworth, and Brian Mitchell

Managing the Dimensions of Innovation

Management of innovation requires a wide spectrum of approaches with different levels of interventions through the firm's lifecycle. The four factors that we have identified are what we consider to be the dominating dimensions of innovation that have to be managed through the corporate lifecycle:

1. **Product Innovation:** research and development

2. **Marketing Innovation:** channel building

3. **Process Innovation:** production and logistics

4. **Financial Innovation:** funding of growth and reinvesting surplus capital

These dimensions are not managed without regard to other business imperatives, but they are the most important for the lifecycle phase the firm is in. Figure 1 shows the egg shape formed by the dimensions of innovation management. The oblong shape illustrates that, depending upon the lifecycle phase the firm is presently in, certain dimensions are more important than others; although the other dimensions still have to be considered, the imperative management focus for the lifecycle phase thus requires a greater proportion of management's attention.

In Figure 1, the "equilibrium" state is shown to indicate the four dimensions of innovation management and the quadrant orientation, but this state is never a reality in the firm's business-management conditions. One dominating dimension needs to be managed with more time, resources, and care to be successful in each stage of the business lifecycle. The curved arrows within each "egg" also show the direction of the management evolution: from product innovation to marketing innovation, to process innovation, and finally to financial innovation. The dotted arrows show the potential for the rebirth of the firm after the Decline stage, but the reality is that the firm either reinvents itself or is liquidated and closed.

In the Introduction stage, focus on product innovation management is the prime concern. As the firm transitions in the lifecycle from the Introduction to the Growth stage, the management focus also has to evolve. This shift is not instantaneous, but will take varying spans of time to complete. Once fully transitioned, as shown in Figure 1, the management focus can be rightly applied to the market imperatives for the success of the firm in the lifecycle stage they find themselves in. As the firm evolves to the Growth stage, management continues to focus on the product itself, with less emphasis on innovation as the product adapts to the existing channels. Market uptake can lead to Moore's "tornado" (2005; tinyurl.com/lzstrav), where the

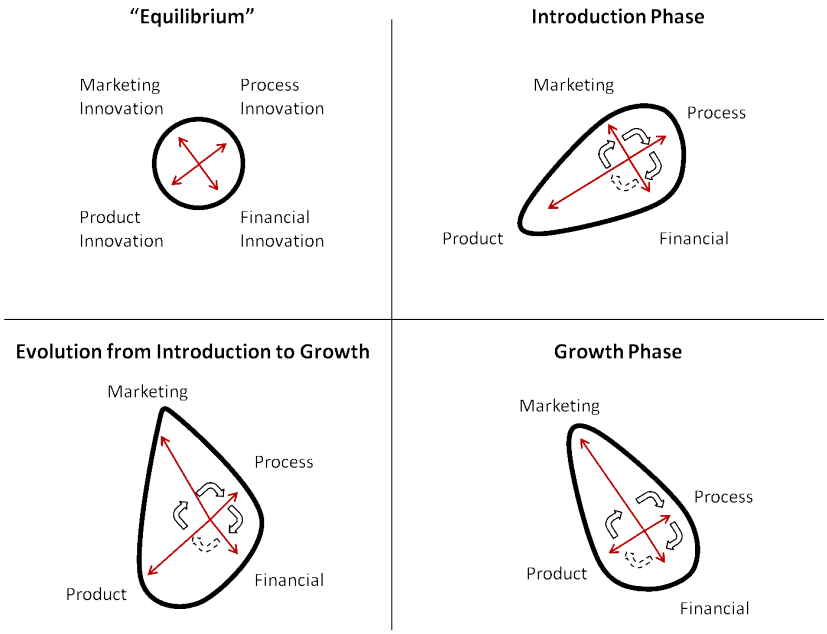


Figure 1. The dimensions of innovation and the evolution of management's "egg-shaped" focus through a firm's lifecycle

Corporate Lifecycles: Modelling the Dynamics of Innovation and Its Support Infrastructure

Tamas Koplyay, Lisa Chillingworth, and Brian Mitchell

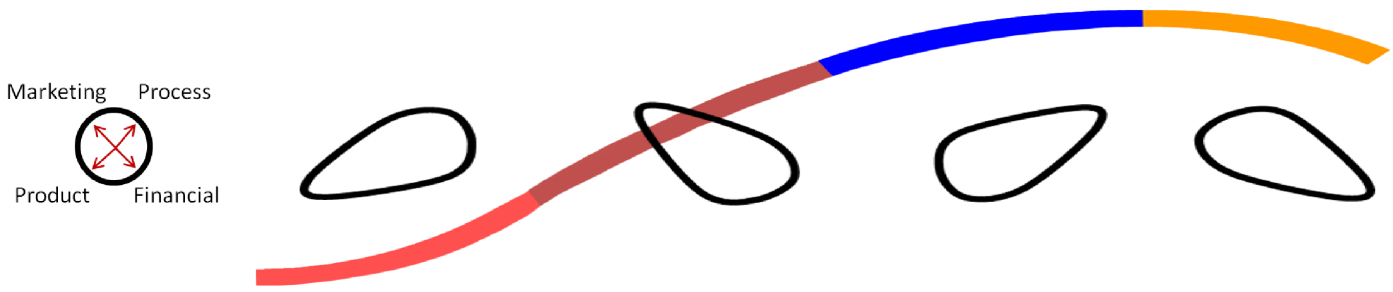
product suddenly gains traction in the marketplace, and increases in demand lead to mass marketing, meeting production targets, and pursuing market segmentation.

The "egg" or oblong shape plays an important role in what happens to the firm in the market space. The concept of the egg shape is analogous to how management has to make decisions in the lifecycle. The oblong shape allows for the forward motion by transferring the motion "up" and providing momentum to the next stage. When moving from a focus on Product Innovation to a focus on Marketing Innovation, the motion and weight has transferred to marketing from product development. Once the total focus of management is directed to the marketing efforts, the product development becomes secondary, and the weight of the oblong shape is carried forward, moving towards the next stage. Should the weight remain in product development, then the marketing focus will not be able to be fully engaged, thus creating deadweight that will either pull the firm back to the Introduction stage, or render no forward motion within the market, thus retarding the advancement to the next stage of firm evolution.

Maturity means that the management focus becomes more inward looking and granular towards cost and performance, and is concerned with only incremental innovation. The evolution of management has moved from big ideas to incremental improvement – from blue ocean (Kim and Mauborgne, 2005; tinyurl.com/l7g2kzg) to Kaizen-related process improvements (tinyurl.com/bjakl) – and leaderships follows inexorably. A creative culture supports breakthrough product innovation; a supportive culture underpins the marketing moves, which first are bold and then become cautious; and production-quality focused, incremental innovation is shepherded by both quality and production culture.

Table 1 captures the evolution of the innovation profile along the lifecycle and the dominant function that generates it. The predictive nature of this model is based upon the alignment of management practices and foci during the various lifecycle stages, but the actual success of the firm's product is up to the technology and market conditions that the firm is experiencing. The periods of evolution between stages may allow two dimensions of innovation to be simultaneously managed

Table 1. The changing focus of innovation management through a firm's lifecycle

	Lifecycle Stage			
	Introduction	**Growth**	**Maturity**	**Decline**
Management Focus	**Product**	**Marketing**	**Process**	**Financial**
				
Leadership and Management Style	Outward looking; broad focus, cult of personality; selling the future	Outward looking; supportive, marketing focus; introduction of professional/ functional managers; return on investment	Inward looking; defence of market share; highly formal and hierarchical; department- or division-based; dictatorial	Inward looking; corporate value maximizing for sale or liquidation; disconnection from workforce
Innovation and R&D	Large technical gains; pursuit of any opportunities	Product and variant development; fit to existing channels; reliability enhancements	Incremental innovation in production or delivery; highly controlled; high levels of review and acceptance prior to implementation	Highly constrained; little or no R&D; potential to sell intellectual property; spin-off
Corporate Culture	Unstructured; achievement-based	Formalization of corporate identity and behavioural norms	Lean or Taylorist; task-based, individual-performance judged	Adversarial; rigid roles and job descriptions

Corporate Lifecycles: Modelling the Dynamics of Innovation and Its Support Infrastructure

Tamas Koplyay, Lisa Chillingworth, and Brian Mitchell

for a short period of time, but as the lifecycle continues, the dominant dimension of innovation has to take precedence over others. Should a firm not evolve their approach as they move along the lifecycle, they run the risk of atrophy or even regression within their market. As well, focusing on more than one management dimension after evolving to the next stage of the lifecycle will result in negative effects, because time and effort will be expended without moving the organization forward; a second focus will either detract from the main focus or require additional resources.

Figure 2 shows possible failure scenarios using the "egg model". Firms splitting their innovation management focus without additional resources will lose opportunities, whereas firms adding resources will then lose efficiency for labour costs. In Figure 2A, pursuing two dimensions fully may result in additional product innovation while market innovation is being pursued, but the efficiency and efficacy of incurring the additional product-development costs may demonstrate the law

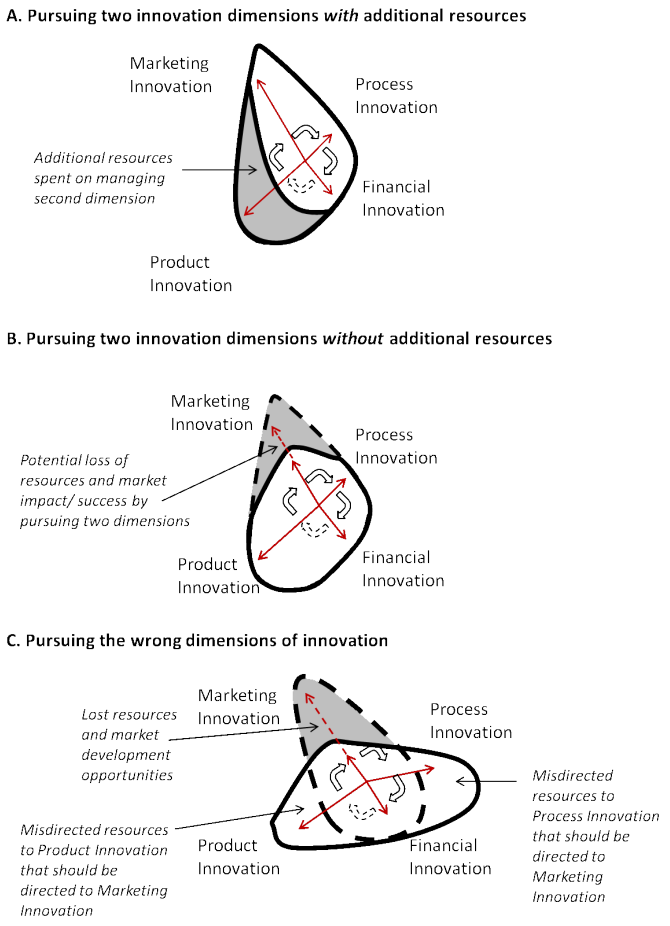


Figure 2. Possible failure scenarios when a firm focuses on two dimensions of innovation or the wrong dimension

of diminishing returns, as well as requiring a reworking of marketing initiatives. Figure 2B shows the loss of Marketing Innovation effort if two dimensions are pursued without additional resources. By splitting its focus, a firm could realize proportionately less ultimate success than the percentage of effort due to inherent underfunding of the most important innovation search. Figure 2C shows the loss of Marketing Innovation and the costs of pursing the wrong innovation dimensions.

One observation of the "egg" shape is that, by allocating the resources to the proper dimension, the process will create or maintain motion to the next stage: the egg will continue to roll. The flatter the resultant shape, as shown in Exhibit 2C, the less motion it can create through natural progression, and the egg will remain stationary. Should the weight be distributed to the wrong side, as shown in Exhibit 2A, the more it will want to roll backwards and return to the previous dimension, thus regressing in the market and perhaps leading to early decline.

Conclusion

In every firm, there is either a culture that supports the innovative efforts of the firm or a culture that cannot understand or adapt to innovation due to a non-alignment of their corporate culture or leadership. As we have shown in this article, both the leadership and the culture have to align to the lifecycle stage that the firm is experiencing in order to maximize support for innovation. Innovation changes from the Introduction stage, where boundary-stretching leadership allows creative people to pursue opportunities and technical advances; Growth means formalization of behaviour and more professional management; Maturity focuses on defending market share and incremental innovation, and is usually focused on cost leadership; and Decline attempts to maximize value for closure or a rebirth. In every stage, even Decline, there can be innovation that either moves the firm forward or staves off closure. The model, as illustrated graphically, shows the strategic imperatives that firms must address in each stage of its lifecycle, and it shows how an unbalanced approach to innovation when combining culture and leadership will result in the forward motion being either slowed, or permanently retarded, to the detriment of the firm. Although the model allows for the evolution from one stage to the next, the logic supporting the model dictates that not more than one primary strategic direction, or innovation dimension, should be pursued at any one time in order to maximize the firm's ability to succeed in addressing the dynamics of innovation.

Corporate Lifecycles: Modelling the Dynamics of Innovation and Its Support Infrastructure

Tamas Koplyay, Lisa Chillingworth, and Brian Mitchell

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Using Boundary Management for More Effective Product Development

John Thomson and Vince Thomson

> *"Simply pushing harder within the old boundaries will not do."*
>
> Karl E. Weick
> Organizational theorist

Twenty years ago, most companies developed their own products in a single location and brought them to market themselves. Today, original equipment manufacturers (OEMs) are enlisting partners on a global scale as subsystem designers and producers in order to create and deliver new products into the market more rapidly and more frequently. This is especially true for large, complex products from the aerospace, telecommunications, electronics, and software industries. To assure the delivery of information across organizational boundaries, new coordination mechanisms need to be adopted (boundary management). In this article, best practices are described on how OEMs and partners self-organize and use agile, cooperative techniques to maintain daily communication among numerous internal and partner engineers to better coordinate product design and system integration. This article focuses on examples from the aerospace industry; however; these tactics can be applied in any organization to innovate at faster rates, to make delivery times more predictable, and to realize shorter product development timelines.

Introduction

Competition in business is nothing new, and building a better product than your competitor has long been a key competitive edge. Over the past couple of decades, to achieve better competitiveness, product developers have put more focus on time, in particular, on rapid product development and timeliness. If developers can achieve rapid development, they can minimize cost risk, and when priority is given to timeliness, developers minimize the risk associated with the poor timing of entry to market. To realize both of these goals, large amounts of resources need to be managed over short periods of time. As development cycles have become even shorter, most original equipment manufacturers (OEMs) cannot physically amass the required resources or cannot justify the cost risk; so, OEMs have been seeking partners for every aspect of creating and bringing a product to market: technology, design, manufacturing, and marketing. Thus, partnering is being used to respond to the pressures of time, and also, to the complexity of amassing the required skills for product development (Littler and Leverick, 1995; tinyurl.com/kvs5yye).

In 2004, the market demanded a new generation of regional jet aircraft with lower operating cost and with a seating capacity of 100–150 people. Bombardier Aerospace (aerospace.bombardier.com) saw an opportunity and realized that due to lower-cost competitors in Russia and Brazil, the time to respond to the demand was short (Pritchard, 2006; tinyurl.com/l7oftco). However, following a corporate restructuring in 2003 and the need to develop two new business aircraft models, Bombardier lacked the resources to launch a new product line (Hébert and Taleb, 2009; tinyurl.com/m5qmwdc). Therefore, Bombardier chose to adopt partners who could completely design and build systems for its CSeries aircraft. Doing so allowed the company to share the financial risk with its partners (Pritchard, 2006; tinyurl.com/l7oftco). Without partnering, Bombardier would not have been able deliver the CSeries aircraft while simultaneously developing two other aircraft.

About the same time, Apple Inc. (apple.com) chose partnering for both the design and manufacture of the iPod, but this was for strategic and not financial reasons (Aboulafia, 2005; tinyurl.com/qxzgqdy). Not even President

Using Boundary Management for More Effective Product Development

John Thomson and Vince Thomson

Barack Obama could coax Apple's then CEO, Steve Jobs, to repatriate the manufacturing jobs from China back to the USA (Rawson, 2012; tinyurl.com/8xfvl45). The reason that Apple chose their Chinese manufacturing partner, Foxconn (foxconn.com), was based on who could build the greatest number of Apple products (e.g., iPhones, iPads, iPods) within the shortest period of time, while remaining flexible and adaptable to Apple's needs. Foxconn had the resources and could manufacture with a greater speed and on a larger scale than any US manufacturer (Rawson, 2012; tinyurl.com/8xfvl45). Foxconn proved its ability to adapt quickly to Apple's requests by needing only 15 days to hire 8700 industrial engineers to oversee the manufacturing of Apple's products. By contrast, Rawson (2012; tinyurl.com/8xfvl45) observes that it would have taken months to find that many qualified people in the United States.

In this article, we adopt the view of collaborative product development as suggested by Lawton Smith, Dickson, and Smith (1991; tinyurl.com/nr9haom): a collaborative relationship between firms aimed at innovation and the development of new products. In a review of literature on the topic of collaborative product development, Büyüközkan and Arsenyan (2012; tinyurl.com/ozjful5) list many characteristics: motivation, risks, and team infrastructure, as well as success factors. In terms of success factors for product development, there are: partner selection, relationships, leadership, trust, communication, etc. In this article, we focus on the daily procedures that are needed to make product development successful when working with partners. We focus on inter-team relationships and communication, in short, boundary management. Communication among design team members is supported by a large set of information-technology tools that include product-lifecycle management, project management, and databases, which we assume that companies use, but are not part of the discussion here. Our information and examples are drawn from the field of aircraft development due to our experience in this area; however, the concepts can be generalized to any industry that features technology innovation and product development.

Boundary Management

Boundary management is the use of coordination mechanisms to assure the delivery of material and information across organizational boundaries (Holland et al., 2000: tinyurl.com/kghevyy; Ancona and Caldwell, 2007: tinyurl.com/mv237nc). For product development, this is the assurance of information transfers between knowledge workers in terms of quality and timeliness. Ancona and Caldwell (2007; tinyurl.com/mv237nc) indicate that much research shows that delay in product development comes from the difficulty in coordinating the various groups involved. They also conclude that "the importance of boundary management… should not be underestimated" and that "high performing product development teams generally carry out more external activity than low performing teams".

Organizations create structures to execute and support activities, where differentiated activities and structures are a result of the division of labour paradigm. Given the tendency to have highly differentiated structures and large physical distances between development teams due to globalization and partnering, timely and extensive communication across boundaries is imperative in order to have successful product development. This assertion is underlined by many authors (e.g., Sosa et al., 2002: tinyurl.com/pfbmahw; Clark and Fujimoto, 1991: tinyurl.com/po3fl48; Wheelwright and Clark, 1992: tinyurl.com/ohttw3u; Ulrich and Eppinger, 1995: tinyurl.com/mks6ees; Antaki et al., 2010: tinyurl.com/l7dtlub).

Some of the research literature on collaborative product management discusses conflict management (e.g., Lam and Chin, 2005; tinyurl.com/nn9hzse). However, we disagree with the use of the term "conflict management" when applied to design activities. When designers collaborate, designs are not created instantly, but are the result of a refining process in which many decisions are made with respect to geometry, quality, manufacturing methods, etc., by many participants who have intersecting interests in the design of a particular system component. This refining process is not a set of incompatibilities or confrontations that need to be settled, but rather requires a large number of communications and cooperative decisions. Boundary management provides mechanisms to identify and facilitate these communications and decisions, while minimizing negative impacts on designers such as schedule disruptions and high levels of interruption for consultation.

Conventional Versus Collaborative Models of Product Development

With the adoption of partners and collaborative product development processes, boundary management becomes very important for successful outcomes. Nevertheless, most organizations do not have the correct culture to perform boundary management well.

Using Boundary Management for More Effective Product Development

John Thomson and Vince Thomson

Figure 1 shows a schematic of a conventional design process. Starting at the top, engineers develop design models and produce drawings and reports using various forms of analysis. The models and analyses are passed to integrators who ensure that interdependencies among parts are harmonized so that subsystems work well together. Once designs are approved, production planning is done, and then, parts are made or purchased. When the parts are ready, the products are assembled. In this model, integrators are responsible for assuring timeliness and the level of quality. There are usually no formal processes for the required communication; the integrator relies on personal relationships with engineering and other groups, and each integrator decides on the form and frequency of communication.

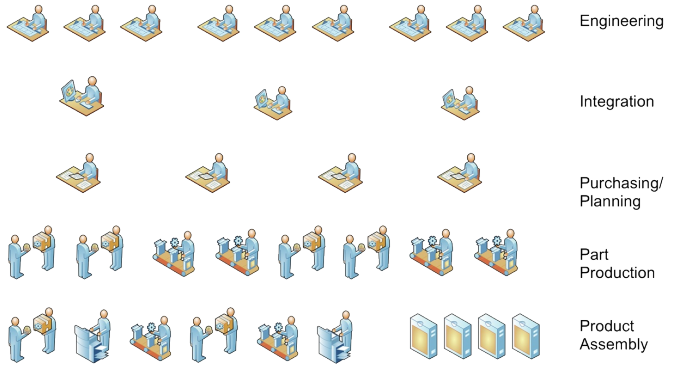

Figure 1. A conventional design process for product development

Figure 2 shows a schematic of a typical process for product development that uses partners. In this case, Companies A, B, and C do the engineering and analyses for product development and their integrators make sure that subsystems will perform as required. Partner integrators forward documents during each design stage to OEM integrators, who give these documents to OEM engineers to review and approve the designs and analyses, confirming that designs meet requirements and that subsystems are harmonized. When designs are finished, it is usually the partner who makes the subsystems and delivers them to the OEM for assembly, or sometimes, the final product is assembled by a contract manufacturer. The supply chain makes sure that parts and subsystems are produced on time at the correct quality for assembly.

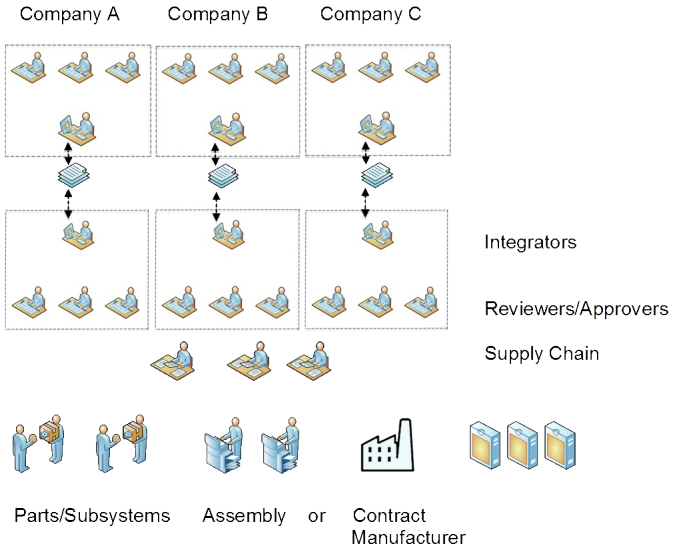

Figure 2. Product development with partners

The main differences between conventional and partnering product development are summarized in Table 1. In the past, most companies have used a conventional process similar to that shown in Figure 1 for product development, where coordination of activities is done on an informal basis. With a conventional process, there is no culture to deal with interactions with collaborators, no formal recognition of boundaries, and no formal mechanisms for managing the flow of information. When moving to product development with partners using a collaborative process, these informal communication mechanisms do not adequately address the needed coordination across more complex boundaries. A culture of boundary management is missing and is often not developed when moving to higher levels of partnering and collaboration.

Table 1. Major differences for OEMs when using conventional and partnering product development

	Conventional	**Partnering**
Resources	In-house	Outside companies
Control	Internal supervision	Contractual partnerships
Activity	Create drawings and parts	Review drawings and documents that specify parts
Focus	Product development	Product development

Using Boundary Management for More Effective Product Development

John Thomson and Vince Thomson

The Review-Approve Process

An integral part of the process of developing complex products with partners is the review-approve process. On a macro-level, the OEM creates the ideas for a new product, contracts the design and building of the product to its partners, and then approves the subsystems built by the partners prior to their assembly into a final product. On a micro-level, for each item, the OEM gives the partner a description of the required appearance, materials, and functionality, then, the partner submits the finished design, and company integrators review and approve it. OEM and company integrators are responsible for moving the design forward between all the development stages: conceptual, preliminary, detailed, production, subsystem test, and assembly, where reviews occur at each stage of the process. Figure 3 shows the exchange between company and OEM integrators where, throughout each stage, many documents are exchanged as the design progresses. For aircraft development, this process involves tens of thousands of documents. Without formal processes for boundary management, the timely creation, delivery, and review of design documents is very difficult to achieve.

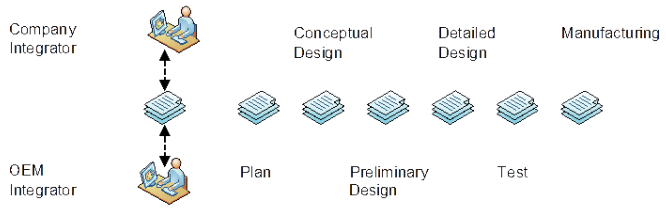

Figure 3. Processing documents in the review-approve process

Boundary Management Issues

Partnering results in several new issues facing both the OEM and its partners. To find the best partner, an OEM must be prepared to search globally, which requires it to create new types of relationships. This change in relationships due to global partnering leads to greater complexity in managing ever more diverse supply chains. The following subsections discuss some of the major boundary-management issues faced during product development.

1. New models for collaborative work
As discussed, OEMs are shifting from being designers and manufacturers to being work reviewers and approvers. In order to assure the seamless integration of subsystems developed by several partners, there must be continuous interaction among developers for the planning and execution of design tasks. Formal processes or procedures are necessary to ensure universal use of effective work scheduling and communication techniques with partners.

The adoption of agile methods (tinyurl.com/ddd3m) for aircraft development has proven successful; weekly schedules are set for intermediate deliverables and daily scrums expose roadblocks. The immediate surfacing of problems that hinder work is absolutely necessary in order to overcome the high interdependencies among the design characteristics of various subsystems. The use of highly specific instructions from the OEM and the quick resolution of common issues assure that subsystems integrate seamlessly. The intent of boundary management in product development is to move relationships from being a contract-deliverable model to that of cooperative work, where appropriate mechanisms greatly enhance coordination for both the scheduling and pace of work.

2. New skills for partners and OEMs
When product development with partners is adopted, there is a significant shift in the roles of engineers for both the OEM and the partners. Partners are now doing the design and production of parts, and the OEM is using a review-approve process to ensure intended functionality and quality. The skills of both partners and OEMs must be upgraded. The partners need people who can lead design teams and the OEMs need people who can review the work of others, where reviewers need to have technical skills superior to designers, for they need to be able to resolve integration issues, which designers do not do well or for which they are not responsible.

Boundary-management skills are required by both the OEM and partners. It should be obvious that integrators on both sides need to be great communicators. Engineers and integrators need to resolve problems with regard to misunderstood design requirements and any uneven pace of work. So, both partners and OEMs must concur on and adopt coordination mechanisms (e.g., schedules, daily meetings, issue-escalation processes) that set an agreed pace of work as well as identify and resolve roadblocks quickly.

3. Partner agreements
Choosing the right partners is crucial. OEMs must create a new type of agreement that is based on cooperative work rather than a specify-and-deliver relationship. Are present suppliers willing to move to this type of re-

Using Boundary Management for More Effective Product Development

John Thomson and Vince Thomson

lationship? Do they have the required skillsets? What conditions need to be negotiated to ensure success in the new arrangement, where success depends on higher competency, a new attitude towards collaboration, and new procedures to ensure good cooperation?

4. Project management
As mentioned, collaborative development requires new coordination mechanisms to deliver on time with requisite quality. More emphasis needs to be given to the ongoing management of process activities for timeliness and quality rather than wait for surprises at delivery. Project management of product development needs to move from a specify-and-deliver relationship where lateness and defects on delivery can be expected to one that emphasizes on-time delivery and first-time quality. Staff on both sides of the boundaries in the design process must adopt new skills for managing information flow.

Selecting a Partner

Once an OEM has decided on collaborative product development, the selection of partners becomes crucial. For now, both the OEM and partner are responsible for innovation, timeliness, and management of the increased pace of delivering to the marketplace. A well-chosen partner can drive a company to market leadership and long-term profitability, whereas a badly chosen partner can lead the OEM to disaster.

Below are some key considerations for selecting a partner with an eye on boundary management.

1. Direct evidence of the ability to use boundary management
A partner's ability to use boundary management can be discerned directly by the degree to which their organization has been structured to allow for communication:

- Dedicated personnel: Is there one or more individuals within the organization dedicated to ensuring communication among design teams?

- Collaborative systems: Are systems in place that assist collaboration?

2. Indirect evidence of the ability to use boundary management
A partner's ability to use boundary management can be discerned indirectly by looking at other factors:

- Success of past projects: How well or poorly has a partner fared in collaborative product development with other OEMs? Have they demonstrated that they can support the complexity of designing products similar to yours?

- Supply chain management: Supply chain management must move beyond purchasing to cooperation for mutual benefit as well as use boundary management to coordinate schedules and pace of delivery. How well do potential partners perform?

- Training in boundary management: Does the partner's training program include boundary management?

3. Selecting a partner to manage risk
One way of evaluating a potential partner is to consider how that partner helps the OEM to manage risk both strategically and operationally. The two main risks discussed in this article are cost and time to market, which are helped by good boundary management:

- Cost risk: Which partners have proven their ability to create accurately designed products in a short time?

- Time-to-market risk: Do partners have the competency and, especially, the attitude to manage development processes in order to deliver on time? Look at the past performance of potential partners to manage timeliness well.

Conclusion

OEMs are working more and more with partners to manage the risks of product development. Collaboration helps an OEM to better handle risk, but it requires better management skills, especially for the complex interactions between OEM and partner design teams. One of the key success factors for collaborative product development is the use of formal procedures for boundary management. OEMs and partners must use boundary management on a daily basis in order to enhance coordination for both the scheduling and pace of work. The successful use of boundary management depends on choosing the correct partners who will enthusiastically develop good working relationships and who will embrace boundary-management practices. Boundary-management tactics can be applied in any organization to innovate at faster rates, to make delivery times more predictable, and to realize shorter product development timelines.

Using Boundary Management for More Effective Product Development

John Thomson and Vince Thomson

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Measuring Innovation Skills Acquired by College and Polytechnic Students through Applied Research

Robert Luke

> *"The goal of education is to make people privately happy and publicly useful."*
>
> John Godfrey
> Educator, journalist, and politician

This article provides an overview of how colleges and polytechnic institutes are fostering innovation literacy via support for business innovation, and it outlines models for measuring innovation literacy for improved downstream innovation and productivity in industry. The article demonstrates how we can innovate innovation by taking a specific, proactive, and instrumental approach to fostering business innovation and skills acquisition gained through applied research work experience by students as part of their college education. This approach is being used by George Brown College in developing a framework for measuring this innovation potential with a long-term, outcomes-based analysis.

Introduction

The past decade has seen increasing investment in applied research in Canadian colleges. A primary output of applied research conducted in the college system is the impact on highly qualified and skilled personnel (HQSP): the students and graduates of programs that engage in applied research with industry partners. Although HQSP can be considered an input to business innovation, it is important to understand how HQSP are also important outputs of the college system. HQSP engaged in applied research at a college gain useful skills as an outcome of this experience. The ultimate outcome of this experience is increased business innovation. To understand how skills are acquired through student engagement in applied research and the potential downstream impact on firms, we must articulate the kinds of skills and activities that result in applied research activities in colleges.

A key program supporting business innovation in Canada is the College and Community Innovation Program (CCIP; tinyurl.com/3uwknht), which was formally instituted with the 2007 science and technology strategy (Industry Canada, 2007; tinyurl.com/lkz6lqk). The CCIP has two objectives: i) increased R&D and innovation capacity by local firms in a college's catchment area and ii) increased capacity of colleges to engage local firms in applied research. Although there are several significant government funding initiatives that focus on business innovation and applied research activities in colleges (e.g., FedDev Ontario's Applied Research and Commercialization Initiative: tinyurl.com/7qetygt; Alberta Innovation Vouchers from Alberta Innovates Technology Futures: tinyurl.com/3f6kj8a; and Quebec's support for College Centres for the Transfer of Technologies: tinyurl.com/myw55v4), this article will focus on the CCIP as a program that is generally representative of programs that aim to enhance college capabilities in support of business innovation.

There is a two-fold benefit arising from colleges conducting applied research with industry partners: i) industry gains access to talent, facilities, markets, networks, and capital, along with support to launch new products and services into the marketplace, and ii) engaging students in applied research fosters innovation skills (i.e., "innovation literacy") in graduates,

Measuring Innovation Skills Acquired by Students through Applied Research

Robert Luke

thereby increasing the innovation potential of the workforce. In order to understand how these two benefits can be measured, this article provides an overview of the applied research activities undertaken by colleges, how these activities relate to innovation skills, how these skills might be measured in students and graduates, and what subsequent impacts graduates can have on firm-level innovation performance. A logic model is presented that articulates the relationships between activities, skills, and measurement. Such measurement is necessary for the college system to show impact on improved downstream innovation and productivity in industry as part of accountability for innovation programs as linked to education.

Applied Research in Colleges and Polytechnic Institutes

The college system is funded explicitly to engage in applied research with local firms. Applied research is distinguished from basic research in that it is oriented almost exclusively toward commercialization and practical outputs, such as the development of prototypes and the market entry of new products and services. Applied research in colleges is linked mostly to supporting small- to medium-sized enterprises (SMEs), because these comprise the majority of Canadian businesses. Funding for applied research in colleges is linked to engaging firms and requires these firms to match money spent on the activities. Canada's longstanding lag in industry R&D spending provides part of the impetus for applied research by colleges: industry partners are required to match CCIP funding, thereby promoting industry investment in R&D.

Colleges engaged in applied research support a range of services offered to firms as part of helping these firms to commercialize new products and services. The scope of funded, applied research services that colleges offer to firms demonstrates the kinds of activities firms require for innovation and commercialization. As per the two CCIP objectives described earlier, colleges offer these services to business to support innovation focused in their region. Importantly, these applied research services relate directly to the development of innovation skills in graduates; this is a key outcome that is designed to create and foster a resilient regional innovation capacity in local industry. Colleges help firms innovate while giving students innovation skills.

Both the Association of Canadian Community Colleges (accc.ca) and Polytechnics Canada (polytechnicscanada.ca) track metrics regarding applied R&D activities. The activities are linked to capacity development and the provision of applied R&D services. In terms of activities to support firms, Box 1 shows the applied research metrics (or "capabilities") collected annually by Polytechnics Canada to define the types of activities undertaken as part of applied research with industry partners.

Over the course of the past year, a team led by George Brown College (georgebrown.ca) in Toronto, Canada, has developed an online resource intended to enable firms to locate an applied research service provider in the college and polytechnic system. Called the Public-Private Partnership in R&D (P3RD; p3rd.ca), the tool used the activity metrics from the Association of Canadian Community Colleges and Polytechnics Canada as a basis to define the types of services firms need to support applied research and commercialization. The P3RD team used the North American Industry Classification System (NAICS; tinyurl.com/q9v8jta) to orient applied R&D services to particular industrial contexts. We used the inventory metrics for applied research to describe R&D services firms access so that the P3RD system could ad-

Box 1. Inventory metrics for applied research, as collected by Polytechnics Canada

- Proof of concept
- Intellectual property registration
- Feasibility study
- Market identification/research
- Proof of commercial concept
- Application identification
- Technology development / application development
- Modelling/simulation
- Prototype development
- Field testing / technology verification / alpha testing
- Product enhancement
- Beta testing
- Cost avoidance
- Manufacturing process design and development
- Commercial scale-up design
- Certification (products, processes, and services)
- Mass production
- Market navigation
- Marketing assistance
- Technology adoption assistance (adoption of product/process by consumers)

Measuring Innovation Skills Acquired by Students through Applied Research

Robert Luke

opt a user-centred firm perspective. The NAICS was used to delineate the type of industry accessing the site. This enabled us to design the site to support a firm working in a particular industry sector (as defined by NAICS) who needed a certain service, as shown in Box 2.

The activities listed in Box 2 reflect the kinds of applied R&D services offered by colleges in which students are engaged as part of their experiential learning. The list is directly related to the types of skill outcomes associated with college programs. In other words, each applied research service offered to support firms relates to the kinds of skills students will acquire by performing these services. Students work on applied research as part of their program curricula. The demonstration or performance of these skills can be part of their core curriculum or ancillary to it. By specifically linking skills acquired and demonstrated through the performance of applied research conducted for firms, students are encouraged to embrace and understand innovation as it is practiced at the firm level.

The learning outcomes associated with college education are augmented by experiential learning, leading to greater innovation capacity; the hypothesis is that this will lead to greater innovation capacity in the economy in which our graduates eventually will work. These activities should therefore have outcomes and impact in firms, both those that partner with colleges on applied R&D, and those that employ graduates who have experience with providing applied R&D as part of their vocational training. Accordingly, these activities represent the practice of skills relevant to innovation in firms.

When students gain experience with supporting innovation through applied research, they gain "innovation literacy", which is “the ability to think creatively, evaluate, and apply problem-solving skills to diverse and intangible issues within industrial problems and multidisciplinary contexts” (Luke, 2009; tinyurl.com/kq4g7p2). Innovation literacy includes “research, development, problem solving, leadership, and entrepreneurial skills, along with the ability to recognize innovation in work contexts” (Luke, 2011; tinyurl.com/m3tc6az). Innovation literacy encompasses the essential employability skills that students acquire through their work on applied research projects with partner firms. Innovation literacy is an amalgam of skills that encompasses the cognitive, psychomotor, and affective domains of learning; it is the ability to engage in the types of business innovation activities outlined in Box 2.

Box 2. Activities and R&D services offered by colleges, as represented in the P3RD application

Use a business service
- Write a business plan
- Clarify a product, process, or service
- Develop a human resource practice
- Develop a prototype

Develop a digital technology
- Perform data analysis
- Develop an academic technology program
- Collaborate remotely
- Design and develop a manufacturing process

Develop machining
- Work with precision machines
- Perform quality assurance

Get marketing advice
- Perform market navigation
- Study cost avoidance
- Get marketing advice
- Increase adoption of a product
- Map my value stream
- Write a sales pitch

Develop products or services
- Build a model or simulation
- Develop and enhance a service
- Conduct field testing
- Enhance a product
- Beta test
- Develop a product
- Develop a rapid prototype
- Make a 3D drawing
- Make packaging
- Design for commercial scale-up
- Design tools
- Develop a new technology or application
- Develop application identification

Work in manufacturing and production
- Investigate mass production
- Layout a manufacturing plant
- Plan a process or production
- Build robots
- Develop an inventory control system
- Study sensory evaluation
- Work in computer numerical control

Measuring Innovation Skills Acquired by Students through Applied Research

Robert Luke

From Innovation Skills to Firm-Level Innovation

In colleges, applied research is focused on business innovation as an outcome. This outcome presents a measurement challenge insofar as the demonstration of impact of college-supplied R&D services will be affected by many variables outside of the college system's span of control, making direct causation or attribution difficult. Despite this challenge, we can still undertake efforts to link the provision of applied R&D services to the ultimate success of firms in terms of innovation capacity. A useful way to do this will be through college graduates, who can be proxies for our measurement of outcomes, as measured by the acquisition of innovation skills.

Skills acquisition, demonstration, and deployment are well defined areas of research and practice. The Ontario college system articulates essential employability skills (see tinyurl.com/3nvsxk5) as attributes of a college education. The OECD Innovation Strategy (Organisation for Economic Co-operation and Development, 2010; tinyurl.com/otrrs9k) articulates the connection between affective domain skills and the hard and soft skills as key to enabling innovation. These essential employability skills and those skills articulated by the OECD are foundational to innovation literacy. However, there is work to be done in terms of ensuring that both graduates and employers see the links between innovation skills and their effect on productivity in the economy (Dwyer and Luke, 2012; tinyurl.com/lm2qe3c). Of key importance is the application of skills into workplace settings, with a focus on the capacity to engage in innovation and entrepreneurship activities, thereby ensuring that students see the link between applied research activities with firms and skill acquisition as being directly related to supporting firm-level innovation.

Given that the explicit mandate for colleges in Ontario is to ensure that graduates are prepared for the workforce (Ontario Ministry of Attorney General, 2003; tinyurl.com/lqvns6t), our discussion of skills and innovation literacy must be grounded in how these skills and attributes may affect downstream economic performance. This performance will need to be measured both in the firms that partner with colleges on applied research as well as in the graduates themselves. Both of these settings present their own measurement challenges.

There is a compounding variable in the readiness of a college to engage in applied R&D with partners. There are therefore two intertwined variables with each needing discrete treatment: i) the college system's readiness for and effectiveness at applied R&D, and ii) the acquisition of innovation skills in students and graduates. Together, these variables have a downstream effect on firms. The readiness of the college system to engage in applied research is beyond the scope of this article, but what follows is a measurement framework for linking applied research services to skill acquisition and demonstration, with consideration given to downstream impacts on firm-level innovation.

A combination of performance measures and client feedback is seen by evaluation experts as optimal for ensuring quality, productivity, and return on investment (Kahn and McGourty, 2009; tinyurl.com/mewqnpm). There is promising potential for statistical analysis of the link between end-user outcomes and college activities that relates to measuring outcomes of applied research conducted with firms. Given the nature of the activities undertaken within the scope of the CCIP, the evaluation of applied research should focus on practical outcomes (United States National Research Council, 1999; tinyurl.com/kxhcc9u). An outcomes management framework is necessary for us to effectively demonstrate the value of applied research in colleges to Canada's science and technology enterprise. Key audiences include (van den Berg, 2012; tinyurl.com/mlmkvwg):

- Government (funds provider)
- Agency (funds delivery, investment choices)
- University, college research and innovation administration
- Students
- Firms

Each of these audiences requires specific measures and instruments. All need a consistent focus on outcomes.

There is a well-developed framework for linking objectives, activities, and outcomes: the logic model. Logic models are well-established frameworks for evaluation, and they are used widely within the Government of Canada. For example, the Treasury Board of Canada Secretariat publishes detailed descriptions of their approach to performance management, including the use of logic models (tinyurl.com/k5rx2yd). A program logic model can aid us in defining and articulating the links between the activities, outputs, and outcomes associ-

Measuring Innovation Skills Acquired by Students through Applied Research

Robert Luke

ated with applied research and the acquisition of skills by students. Such links are important to all audiences listed above. Tracking outcomes against stated objectives lets us link inputs to outputs and ultimately outcomes and impacts.

The following components of a logic model are used to measure progress towards a desired objective over time:

1. **Purpose:** the strategic aim/objective of change/effect to be measured

2. **Inputs:** the parameters/projects in which we invest to effect change over time

3. **Activities and participants:** what is done and who does it

4. **Outcomes/impacts:** what happens over time. These objectives are typically structured as immediate, intermediate, and ultimate outcomes. The ultimate outcomes are directly related to the purpose.

These elements of a logic model provide a tool for linking the applied R&D activities supported by colleges for firms and the skills students gain as a result of engaging in this form of experiential learning. A key aspect of this approach is that it allows us to test – over time – the acquisition and demonstration of skills by students, through to downstream innovation support in firms after the students have graduated. Thus, this approach allows us to develop a logic model for training highly qualified and skilled personnel (HQSP) through applied research, as shown in Table 1.

Measurement components

There are several components to our logic model for measuring the acquisition of innovation literacy skills and their deployment in firms post-graduation. The components presented below are from work conducted to date on measuring innovation literacy in students and graduates:

1. **An innovation skills measurement tool:** The Conference Board of Canada's General Innovation Skills Aptitude Test (GISAT; tinyurl.com/metjy87) offers a tool to measure the acquisition of skills and their application in firms. The Conference Board of Canada has recently updated their Innovation Skills Profile (tinyurl.com/q7yhafk), which provides a basis for understanding the kinds of skills relevant to fostering innovation in firms and how these are related to applied research activities as noted above.

2. **General and college-specific key performance indicators (KPIs):** The provincially mandated KPI survey offers a rich dataset that lets us examine how students and graduates feel about the acquisition of the skills that comprise innovation literacy. We can use the KPI survey questions that are relevant to skills acquisition to link to innovation literacy skills acquisition as measured by the GISAT. Whereas the GISAT can be deployed specifically to students engaged in applied research, the KPIs provide a context or baseline against which to measure the general population. In addition to the KPIs as provincially mandated, colleges are allowed to put in five college-specific questions asked only of their students and graduates. George Brown College has included questions that ask students and graduates if they participated in an "Applied research project/course project with industry" and if so, what is their level of satisfaction with the experience. We also ask this of employers.

3. ***Toronto Next* survey:** In October 2012, George Brown College released the results of a survey of Greater Toronto Area firms and their understanding of innovation and productivity, and the inputs required for these. *Toronto Next: Return on Innovation* (2012; tinyurl.com/p49grd6) gave us several key insights into how firms in the Greater Toronto Area value productivity while not necessarily valuing the inputs required for it: innovation skills, skills training, R&D, and investments in new equipment and technology. Elements of the *Toronto Next* survey will be redeployed to partner firms who are engaged with colleges in applied research. The resulting data will enable us to gain an understanding of a firm's level of interest in and understanding of the innovation inputs that lead to productivity outputs.

The logic model for training HQSP through applied research requires the collection of metrics from both within and outside the colleges. Internal measurement enables a view of the form and function of the applied research system in colleges. External measurement allows us to track the outcomes and potential impacts the activities lead to, outside of the colleges themselves and in the larger community. For colleges, each set of measurements has its own purpose. The internal measurements provide a view toward program delivery, standardization of applied research services and student experience and the acquisition of innovation skills; the external measurements ensure that outcomes and objectives as stated by the CCIP are met and that performance can be managed accordingly. Thus, al-

Measuring Innovation Skills Acquired by Students through Applied Research

Robert Luke

Table 1. A logic model for training highly qualified and skilled personnel (HQSP) through applied research

Purpose	Foster innovation literacy in students while improving firm-level innovation		
Participants	**Students**	**Firms**	**Measure**
Inputs	Faculty with interest in applied research Funding to support student engagement in applied research Projects and placements with firms Business development to support firm engagement	Projects and innovation support needed	Students: GISAT (pre/post project engagement measurement) Firms: TO Next survey
Activities	Project involvement through curricula, paid work, internship	Project engagement and support of students' learning	Activities are defined with the taxonomy (above) as per applied research services offered by colleges
Outputs	Students produce products, prototypes, services for firm partners, as linked to learning outcomes	Products, prototypes, services created for market entry	Skills articulated (students) against output metrics (firms) collected as part of applied research activity
Immediate Outcomes	Students gain innovation literacy skills; can articulate these and demonstrate proficiency	Firms commercialize new products or services	Students: Awareness of skills acquisition; Number of students engaged in applied research Firms: Successful market entry of new product or service
Intermediate Outcomes	Graduates gain jobs as a result of gaining innovation literacy skills	Firms that employ (or startups started with) students with applied research experience have greater innovation capacity	Students: Number of jobs and startups Firms: Number of employees hired
Ultimate Outcomes	Graduates are more likely to start a company or work on innovation activities within a company	Partner firms innovate, conduct R&D, and bring new products and services to market	Students: GISAT measured over time, as linked to employer innovation performance Firms: greater likelihood of participating in innovation and enhancement of the Canadian innovation system

Measuring Innovation Skills Acquired by Students through Applied Research

Robert Luke

though there is consonance between both external and internal views of the logic model, and there will be useful overlap in the instruments we use to ascertain value and return on investment, it is important to measure indicators relevant to both internal and external perspectives. Certainly, the internal outcomes relate to the ability to deliver on the external outcomes. Both are necessary; neither alone is sufficient. We invite discussion and debate on the most useful and useable way to measure the acquisition of innovation in graduates and how best to demonstrate the results to external audiences.

Why It Is Important to Measure the Impact of Applied Research in Colleges

Measuring the effectiveness of the applied research system in colleges is relatively new: it was formally supported through the CCIP starting in 2007. However, as yet, there are no externally valid and reliable data to show impact. A report by the Council of Canadian Academies (CCA; scienceadvice.ca), titled "The State of Science and Technology in Canada" (2012; tinyurl.com/8bupudg), provides "a thorough analysis of the scientific disciplines and technological applications where Canada excels in a global context. It also identifies Canada's science and technology strengths, regional specializations, and emerging research areas". The expert panel that prepared this report was charged with ascertaining Canada's strengths in both basic and applied research. Colleges were included given the focus on federal funding of applied research in the college system since the publication of the Industry Canada's strategy report: "Mobilizing Science and Technology to Canada's Advantage" (2007; tinyurl.com/k9hame8). The CCA's 2012 report was a thorough and in-depth, evidence-based analysis of Canada's science and technology capacity. The measures for basic research are well defined and resulted in strong observations about research excellence. The measures for applied research, however, were limited, particularly when it comes to technology development (CCA, 2012; tinyurl.com/k4v47x2). And, although the college system was included in the report, the data for applied research conducted in colleges are not well defined:

"*Canada's colleges and polytechnics have been undertaking an increasing amount of applied S&T* [science and technology] *in recent years, often in cooperation with local businesses. Due to the growing importance of this activity to their overall role in the Canadian higher education landscape, colleges and polytechnics are now actively monitoring and recording many metrics related to applied S&T outputs.* […] *Most of these other sources of data on applied R&D activity in Canada's higher education sector and public research organizations are not broken down by the field or type of research. As well, in many cases, data are available only for specific institutions, sectors, or regions, and are not available consistently across the country. As a result, while general statistics of this kind may illuminate certain facts about Canada's applied R&D strengths in specific institutional settings, their piecemeal nature precludes a systematic identification of Canada's research and technology strengths. The Panel thus concludes that there remains a need for more systematic and detailed data collection of metrics related to applied research and technology development activity in Canada.*" (CCA, 2012; tinyurl.com/k4v47x2)

The challenge faced by the college system, then, is to come up with measures that can be used for future assessments. These measures will need: i) to be easily and consistently applied and collected across the country; ii) to be segregated by industry; iii) to focus on impact and outcomes (i.e., not just activities); and iv) to stand externally as viable measures of success. It will thus be increasingly important to link applied research activities to student learning outcomes given the growth trajectory of applied research in colleges. In so doing, we can innovate innovation by taking a specific, proactive, and instrumental approach to fostering business innovation and skills acquisition gained through work experience in applied research.

Conclusion

There are two key outputs for colleges engaging in applied research: i) the support of firm-level innovation and ii) the training of highly qualified and skilled personnel, who gain innovation skills ancillary to their program outcomes. As noted above, these skills are directly related to the provision of applied R&D services to firms. The applied research services offered by colleges offer a strong platform on which to base innovation skills, and measuring these skills over time is strongly related to the success of the college system and its ability to provide for the innovation capacity of Canada. The learning outcomes associated with college education, as augmented by experiential learning such as applied research, will lead to greater innovation capacity in partner firms, as well as those firms that employ graduates equipped with innovation literacy.

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Q&A

Tim Ragan

Q. How do you program innovative thinking into company culture?

A. When someone in a business context mentions "innovation", we tend to think about someone like Steve Jobs, Henry Ford, or perhaps Thomas Edison. We often associate innovation with an individual and their force of personality, entrepreneurial spirit, and dogged determination to bend the world to their way. Although that viewpoint fits nicely with our hero-worship romance, it can too easily miss the actual reality of what "innovation" is, and it glosses over the imperative that all leaders face, in terms of their personal role in building sustainable innovation capabilities into their organizations. As excellent leaders already know from personal experience, the ability to continually innovate the stream of products, services, and processes can be programmed into any company by getting the mix right between strategy setting and implementation culture. However, to answer the question of *how* to program innovative thinking into company culture, we must first determine what we actually mean by "innovation" and by extension, what a "culture of innovation" actually looks like in action.

Innovation can be defined as: "the process of translating an idea or invention into a good or service that creates value or for which customers will pay" (Business Dictionary; tinyurl.com/3xnhek9). This definition suggests that innovation: i) is a process and ii) must produce something that creates measureable value that can be economically exploited by the innovating organization. Extending that concept, we can think of a "culture of innovation" as one where we regularly work at developing and implementing ideas that can be translated into value-adding activities for the business.

The key question now becomes: "How do management teams develop a company culture that motivates such behaviour?" The short answer is that programming "innovative thinking" into a company requires management teams to nurture two unique but complementary approaches: i) setting strategy with clarity and discipline, and ii) developing a culture that rewards experimentation and learning through doing. This programming, of course, starts with the executive team. Everyone in an organization witnesses firsthand what actual behaviour is nurtured and rewarded by management, and they evaluate the clarity of the strategies, goals, and objectives that flow down from the top.

Strategy Setting

Executive teams can effectively program the "strategy setting" aspect of innovative thinking into their business in the following ways:

1. Clearly articulating the business strategy and determining where key innovations in product, process, or business approach may drive compelling value.

2. Translating the strategy and the innovation intent into clear, measurable targets and ensuring that everyone understands their roles and responsibilities.

3. Ensuring alignment around that strategic intent and related action plan to help ensure everyone involved shares a common view of the strategy and is able to communicate it.

4. Working with the entire executive team on a regular basis to ensure regular and rapid feedback on implementation progress.

5. Facilitating a regular re-vectoring of the plan based on the real feedback and results gained from the marketplace, external environment, and the organization itself.

However, these activities only describe the mechanics, or process, of programming innovation. Just as we see with software programming, a solid design process must be married with meaningful content to achieve anything worthwhile out of the overall programming activity.

But, what is considered "good content" when working to program a culture of innovation? First and foremost, real innovation comes from envisioning a different game or different outcome and being open about how one might get there, while believing absolutely that the

How Do You Program Innovative Thinking into Company Culture?

Tim Ragan

outcome is both achievable and worthwhile. Innovation is generally not driven purely by market research and focus groups, or incremental improvements; it is more disruptive and game-changing than that. The essence of innovation is best embodied in the statement commonly (mis)attributed to Henry Ford: "If I had asked my customers what they wanted, they would have said a faster horse." (O'Toole, 2011; tinyurl.com/42j6p2b) And, innovation does not only occur with products or services – it can also happen with process innovation.

Effective innovation starts with exploring where dramatic value might be unlocked in the business, if leadership could envision a "different future". This in turn requires:

- a high degree of curiosity, a comfort with probing into inquiries where the answer is unknown (and possibly unknowable)
- a willingness to embark on experiments that may fail
- a bias toward reaching out and collaborating wherever and whenever possible
- a readiness to embrace failure as a learning mechanism and to reward such failure
- proactive management of timeframes such that experiments can be run long enough to clearly prove or disprove concepts, but no longer than absolutely necessary so that resources are not squandered

Therefore, the innovation content is "messy" and, in many respects, is the exact opposite of the business culture that is unwittingly built into many organizations where rewards accrue to those that play it safe, follow the rules, and support only incremental improvements.

Despite the formal statements that companies often tell about themselves about innovative thinking and thinking "outside the box", all too often it seems that the overriding culture might be more accurately summed up as:

"This is the way we've always done it. It worked for us up to now and so the way forward is to do more of it, perhaps just more efficiently. It doesn't pay to experiment because failure is a one-way ticket down the ladder or out of the company. It doesn't pay to challenge the strategy or question things, because I'll be seen as a troublemaker or worse. And if I'm not clear on what I'm supposed to do I'm not going to declare that in public because people will think I'm thick. So, I'll nod in agreement at the right time, and then go off on my own and do whatever I think needs to be done. Luckily, most everyone's goals and objectives are vague and not well managed so if I don't deliver I'll likely be able to blend into the woodwork and blame the general environment as holding me back from delivering."

In a culture like this, the best people ultimately become frustrated and, not being able to find any traction for meaningful change and effective contribution, will most often leave the organization. A high rate of turnover among key employees is a tell-tale sign that significant "cultural rot" may be setting in.

The Structure of Innovative Thinking

Intentionally building a culture of innovation requires the antithesis of the more common "play it safe" culture of most businesses. Working through the major structural elements in more detail allows us to explore both the discipline of strategy setting and the associated experimentation culture that combine to build "innovative thinking". These structural elements can be combined through five steps:

Step 1: Articulate the business strategy and determine key innovation areas

Unfortunately, many business strategies are not clear, precise, or measurable. At the extreme, they are merely platitudes, stating goals as: "we want to be the best in customer satisfaction" or "a clear number 1 in our market". Reasonable statements, to be sure, however they generally do not have the next level of details that addresses questions such as: "What does that actually mean?" and "How do we measure success?" If this detail is missing – and unfortunately in many cases it is – then the probability of achieving these objectives amounts to a slim chance. To further complicate things,the goals are often unclear, as are the methods of measuring progress toward them . The starting point is often also not clear or precisely defined. As an example, a typical "strategic goal" might be presented to the company as:

"Our customer-satisfaction levels are not acceptable. We need to dramatically improve them, and fast. In particular, customers complain a lot about product quality, so we have to focus on that and get a lot better, a lot more quickly. We know what we need to do – let's go make it happen!"

How Do You Program Innovative Thinking into Company Culture?

Tim Ragan

Of course the reality is that once the general cheerleading and enthusiastic demonstrations of support for improvement bleed away, all that is left are vague, empty statements that cannot be easily acted upon. Compare that situation with an actionable business objective such as:

"We need to improve our customer satisfaction levels, as measured by our standard quarterly customer survey and our random phone surveys. We are currently rated at an aggregate of 3.2 out of 5 in our surveys, with particular concern about product quality, which is rated at only 2.1 out of 5. Our business objective is to improve our scores to an aggregate of 4.5 within the next 18 months, and to score a minimum of 4.2 on the product-quality metric within the next 12 months."

With this statement the company has clearly identified goals, targets, and measurement systems.

Step 2: Translate the strategy for innovation into clear targets

Embedded in the business-outcome statement is also a clear area for a potential product, process, or service innovation to add value: within 12 months, the goal is to double product quality, as measured by standard survey question responses. This statement forces the organization to now ask itself, "What actually drives customer satisfaction with the product quality?", and including a requirement for a two-fold improvement helps push people outside their comfort zones and look for non-incremental solutions. Now that a clear goal has been stated, and related success measures have been identified, it is now a straightforward matter to pull together a cross-functional "tiger team" (tinyurl.com/cu3yfz7) of experts, assign an executive champion, and develop a more detailed action plan for targeting this improvement area.

In our example, the tiger team may discover that the largest contributor to the dissatisfaction with "product quality" is in fact the product packaging, due to the sheer volume of over-packing required for transit safety. This finding might prompt the tiger team to consider potential what-if scenarios involving dramatic changes in packing materials, transport options, or other potentially innovative solutions. Ideally, the tiger team will embrace potentially unorthodox approaches, such as: teaming with key customers to experiment with common processes; forming non-traditional teaming relationships within the business to provide a different perspective; and examining how other non-similar businesses and industries set about addressing similar challenges. All of these tactics go to the heart of helping embed and sustain "innovative thinking" into company culture.

Step 3: Ensure alignment of team members and communications

By the very nature of the message – very specific and clear, with measureable outcomes and target dates identified – it is much easier to test alignment across the executive team and to ensure clear and clean communications throughout the organization as to the strategic intent the company is operating within. A common problem in many executive team cultures is one of "malicious compliance", where the strategy is publicly embraced but ignored or actively worked against inside the executives' domain. Again, with clarity about the strategic intent, the objective and small measurable milestones that are published and regularly reviewed, this attitude becomes easier to spot and confront.

At this point, the tiger team has embarked on a number of investigations, each requiring some cross-functional resourcing, given the nature of the investigations. With clear alignment of these projects to the company's strategic imperative of doubling product quality within 12 months, it becomes much easier to secure, support, and defend these resourcing requirements for all involved (e.g., line managers, project participants, executive sponsors), because there is high visibility and commitment to the desired outcomes.

Step 4: Implement a "heartbeat" for rapid feedback

In the course of one week, sales calls can be made, experiments can be planned and started, products can be built, critical customers and prospects can be contacted, and key projects can be moved forward by measureable amounts. Therefore, a weekly measurement discipline can become an ideal "heartbeat" timeframe for most companies. The key to making weekly "heartbeat" meetings successful is to make them an integral part of the executive team's management system – short, regular, with a small handful of critical business metrics tracked and discussed, clear actions taken, and resulting issues taken offline and clearly addressed.

In our example, it is clear that we are not going to improve product quality from 2.1 to 4.2 in a single week, so what can be reported at the executive level that is meaningful? The role of the executive sponsor is to present a very short, meaningful update to the execut-

How Do You Program Innovative Thinking into Company Culture?

Tim Ragan

ive team that will provide transparency about the project and its progress, or lack thereof. The sponsor negotiates with the rest of the executive team to define what constitutes a "short, meaningful update" and presents standard metrics accordingly. The executive team also has an important role in helping to shape the scope and risk of the various investigations and experiments.

In our example, because the doubling of product quality is a stretch goal, it is critical for progress to be reported transparently. It is also essential for everyone to have a clear understanding of the overall portfolio of activities, what might constitute success for each activity, and how each activity contributes to the overall strategic goal. It is the executive sponsor's responsibility to ensure that the tiger team is infused with "innovative thinkers" and has access to the resources it needs to push forward; it is the executive team's responsibility to ensure that the executive sponsor and tiger team have a clear understanding of their approach to their design challenges and related success measures.

Step 5: Regularly update the plan to adapt to reality
In any organization, plans go awry for a multitude of reasons. As Field Marshal Helmuth von Moltke the Elder makes clear: "No plan survives first contact with the enemy." (tinyurl.com/cur325) Moltke was not implying that plans were not important, but rather that it is a matter of having a plan and adjusting it in real time as the picture evolves. Weekly "heartbeat" meetings provide a mechanism for receiving regular feedback and, when progress is slow or the expected results do not materialize, the executive team can have an intelligent, data-driven conversation about whether the plan "as is" still makes sense or must be changed. This moment is when the executive team must put their expressions of support into action and show the tiger team that experimentation trumps the status quo, that rapid exploration and failure is strongly preferred over playing it safe, and that the company culture not only supports but rewards a culture of experimentation.

This weekly routine – and the degree to which the executive team embraces it – is a direct measure of the company's management discipline. The ability to embrace, build, and continually fine-tune this "discipline habit", combined with the ability to build and nurture a real culture of experimentation and "learning by doing", is a core competence of an effective executive team.

Conclusion

With the approach described here, it is indeed possible to program innovative thinking into company culture. A culture that continually seeks to question the status quo, that embraces experimentation and the failure that often accompanies it, that seeks and encourages feedback to provide greater context, and that is unafraid to react to changing circumstances in the pursuit of measureable business success, greatly improves its chances of success. By the very definition of "innovative thinking", such a culture will continue to innovate – that is, to work at continually translating ideas, insights, and inventions into goods, services, and business processes that create value for the company.

About the Author

Tim Ragan is the founder/owner of C-View Strategies (cviewstrategies.com), a business-design consultancy, and he is the owner of Career Coaching International (careercoachint.com), where he helps people discover their talents and interests, and accelerate their career objectives. He has over 25 years of experience in numerous functional, management, and executive capacities on three continents with major communications players including Mitel, Nortel, Newbridge Networks, and Alcatel. Tim has a BSc in Electrical Engineering from the University of Alberta in Edmonton, Canada, and an MBA from the University of Ottawa, Canada, where he teaches "Business & Society", a course that examines the ethical and moral implications of modern business and its interaction with government and civil society. He also regularly teaches graduate-level courses on business-process transformation.

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