

Economics Program Working Paper Series

Signposts of Innovation: A Review of Innovation Metrics

Janet X. Hao
Bart van Ark
Ataman Ozyildirim

The Conference Board

May 2017

EPWP #17 – 01



THE CONFERENCE BOARD

Economics Program
845 Third Avenue
New York, NY 10022-6679
Tel. 212-759-0900
www.conference-board.org/economics

Signposts of Innovation: A Review of Innovation Metrics

Janet Hao, Bart van Ark, Ataman Ozyildirim¹

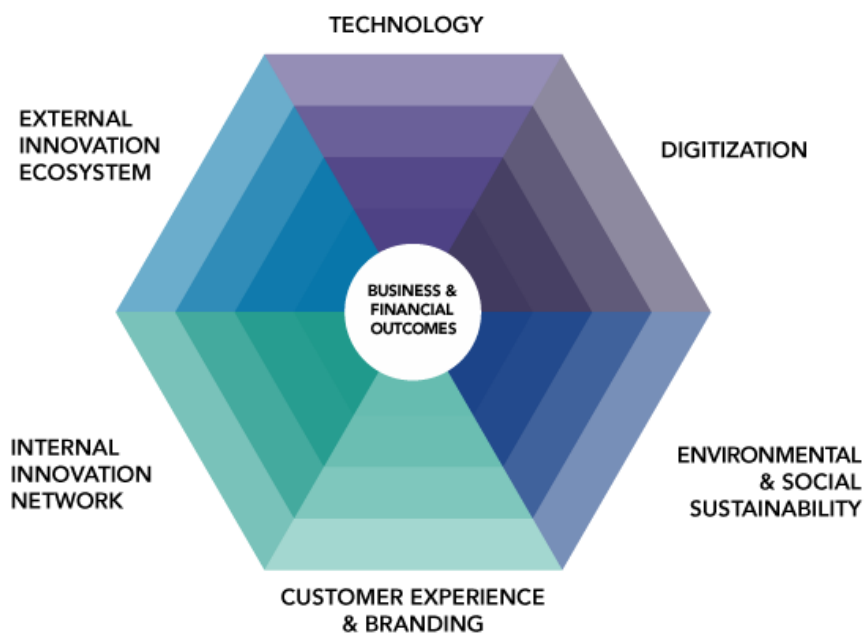
This paper reviews existing innovation metrics at the company-level and country-level, and proposes a system of signposts of innovation to help executives with a guiding framework and data resources for evaluating and planning innovation strategies and activities. The scope of the review is intentionally very broad, ranging from academic papers, policy papers, reports by consulting firms, reports by innovative firms, and magazine articles to capture a holistic view of the complexity of innovation activities that today's businesses undertake. We also incorporate input from The Conference Board members' perspectives identifying some of the most important metrics they currently use or need in the future and identifying signposts around which these metrics are organized. The proposed framework is comprised of six major signposts of innovation (technology, digitization, environmental & social sustainability, customer experience and branding, internal innovation networks, external innovation ecosystems), captures major areas of innovation activities throughout the life-cycle of innovation, and reflects the complexity of new generations of innovation models.

Key Findings

- The innovation process is complex and constantly evolving. The common view of innovation has evolved for five generations over the past seven decades or so from mainly a scientific activity of research and development to a complex system of interactions among various participants both inside and outside of a firm, sometimes with the assistance of advanced IT systems. And, they continue to evolve in the 21st century with the advent of internet enabled technologies and big data and predictive analytics.
- At the country level, major measurement frameworks have evolved with the five generations of innovation processes from the 1950s to the present. Major measurement frameworks are the Oslo Framework and the National Innovation Systems. The macro frameworks treat the innovation processes in companies as a black box.
- The major challenges of country-level measures are to provide timely innovation measures, to capture the new forms of innovation, to present the complexity of the innovation activities, and to measure the whole innovation process including inputs, throughputs and outputs.
- At the company level, major measurement frameworks are the Diamond Model, the idea management model, the Innovation Funnel Model, the Ten Types of Innovations Model, and the model of Dulkeith and Schepurek (2012), to name a few.
- The major challenges of company-level measures are to measure the whole life cycle of innovation, to have a sufficient list of metrics to formally measure innovation, and to keep an overreliance of innovation metrics from impeding the innovation process.
- This paper proposes a measurement framework of six innovation signposts (technology, digital transformation, environmental & social sustainability, customer experience & branding, internal innovation networks, external innovation ecosystems). This framework creates a flexible data structure, positions metrics along the value delivery chain, treats business innovation as part of the business environment, and measures the whole innovation process including inputs, throughputs and outputs.

¹ ©The Conference Board, Inc. Corresponding author: janet.hao@tcb.org We would like to thank Laura Greenberg for collecting innovation metrics, and thank Elizabeth Crofoot, Thomas Singer, and the Senior Fellows of this project for comments on previous drafts. We are grateful to our member companies for participating in the events and interviews that yielded insightful inputs to this project. Our Senior Fellows are Anne Greer, Rita Shor, John Metselaar, Jim Gregory, Erin Grossi, and Carol Corrado.

Figure 1: The Conference Board Signposts of Innovation



Source: The Conference Board.

Motivation

In the current economy characterized by disruptive innovations, changing customer needs, and a slowing trend of global growth and trade, it is crucial for a company to keep up with the emerging trends and stay on top of factors enhancing its own innovation capacity. Strong innovations drive productivity and therefore make their companies more agile and resilient against shocks, disruptions and the uncertainties that come with it (van Ark, 2016).

Despite the importance of innovation, managing and promoting it in a company is not easy. Most innovation activities count as current expenses and therefore weigh on a company's bottom line in the current year, whereas the payoff is often over multiple years. There is often potential for internal resistance among organizational teams and business units who may find that innovations threaten the status quo. Innovative activities often compete for resources against routine work, making it critical that executives working on innovations at all levels in a company communicate with the top management about the resources (or lack of), barriers, progress, portfolios and returns of innovations.² Such internal communication about measures of innovation can benefit hugely from more comprehensive measures of innovations—measures that are also specific enough to provide guidance for setting a company's future direction for innovation and decisions about allocation of its resources.

This report serves as a background white paper for The Conference Board project on innovation metrics, *Signposts of Innovation – Towards a Flexible and Comprehensive Innovation Measurement System*.³ In the remainder of this paper, we review existing metrics, and organize company-level and country-level metrics into our system of innovation signposts that will provide a guiding framework and data resources that companies can use when evaluating and planning their innovation strategy. The scope of our review ranges from academic papers, policy papers, reports by consulting firms, and magazine articles, with the aim to provide a comprehensive view from academic researchers, policy makers, consulting firms, as well as companies that carry out innovations themselves. In this process, we also benefited from input from TCB members in identifying the signposts of innovation and determining some of the most important metrics they currently use or need in the future (see Appendix A: Table 1). Our review culminates in the six major signposts which are the prime categories of innovation activity (technology, digitization, environmental & social sustainability, customer experience and branding, internal innovation networks, external innovation ecosystems).

The structure of the paper is as follows. Part I describes the changing paradigms of innovation from the 1950s to the present. Part II reviews the existing theoretical frameworks of measuring innovations at the country and company level and discusses our view of a measurement framework. Part III reviews existing indexes and other measures of innovations at the country, industry and company level. Part VI proposes our own measurement framework and signposts. Part V concludes.

Part I: Changing paradigms of innovation

Organizations and companies, depending on their culture, may have different definitions of innovation. There are many definitions of innovation (Dance, 2008), but for the purpose of this study we adapt a relatively simple but broad definition from an earlier study at The Conference Board.

Innovation is broadly defined as an activity or set of activities that results in the creation and use of a new or significantly improved product or service; production or operating process; way of attracting customers by enhancing their experience; and organization practice, work design, human capital competency, or use of resources, that creates value.

(Source: Based on *Designing Global Businesses for Innovation and Growth*, The Conference Board, 2014)

The way companies approach innovation is complex and has changed over time. (Rothwell, 1994) has described this constantly evolving view of innovation by identifying five generations of innovation models (Figure 2). The changes in approaches to innovation are driven by an increasingly competitive environment, new capabilities (such as digitization) and changing customer needs. Thus, the common view of innovation has evolved over the past seven decades or so from research and development that is mainly a scientific activity to a complex system of

² Does your Chief Innovation Officer Feel Like This? <https://execrank.com/board-of-directors-articles/does-your-chief-innovation-officer-feel-like-this/>

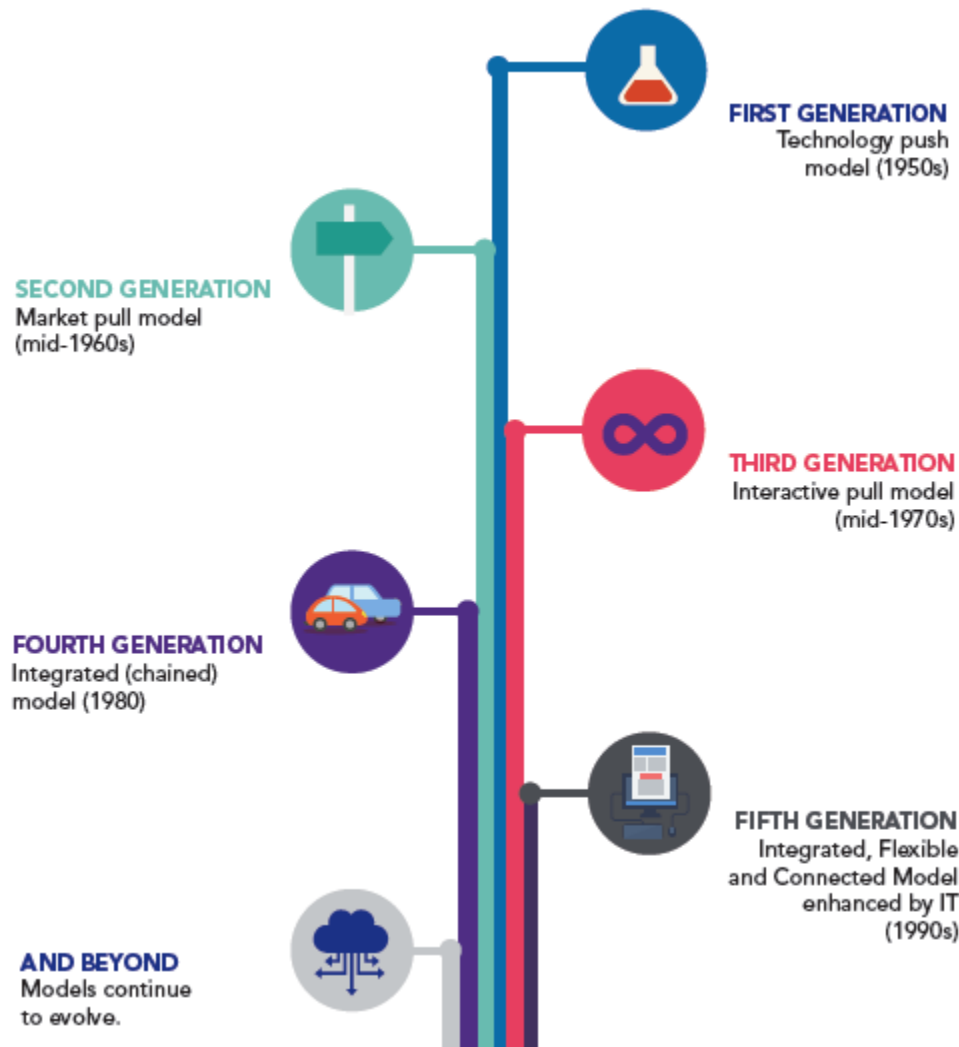
³ <https://www.conference-board.org/future-of-innovation/>

interactions between various participants both inside and outside the firm, sometimes with the assistance of advanced IT systems (Rothwell, 1994). Most companies use a mix of elements from several generations in their innovation activities—their choices determined by their internal capabilities and the demands of their industries and customers. For example, some companies still use the “gate” system to track innovation and the gate system corresponds to the linear innovation models (1st and 2nd generations), because only linear models will allow innovation activities to flow linearly from one gate to the next gate. Nevertheless, delineating the five generations of innovation models, as suggested by (Rothwell, 1994), helps put different types of activities and paradigms in historical context:

- The first-generation of innovation practice - the linear Technology Push Model- arose in the 1950s. The model is motivated by new technology, and the process flows linearly from basic research, to design and engineering, manufacturing, and marketing and sales. In this model, new technology is the major driver of innovation and the market is the recipient of the benefits of the new technology.
- The second-generation is the linear Market Pull Model which emerged in the mid-1960s, as customer taste began to proliferate and customer needs became more diversified. Innovation is more strongly led by market needs, followed by development, manufacturing and sales.
- The third generation is the Interactive Pull Model which emerged in the mid-1970s. It is a combination of the first and the second generation models where new technology and market interact with each other. The innovation model is no longer linear and includes feedback loops among the company, market needs and new technology.
- The fourth generation, the Integrated (Chained) Model, emerged around 1980. Unlike the earlier generations which look at innovation as a sequenced process or a combination of two sequenced processes, the fourth generation model presents the innovation process as a parallel process that integrates the different business functions and external resources, in order to shorten the time span of each innovation.
- The fifth-generation model is the Integrated, Flexible and Connected Model which emerged the 1990s. It combined the fourth generation model with new IT technology which helps enable new forms of innovation such as crowd sourcing, and allows the participation of various players such as suppliers and customers along the value delivery chain. It is a more collaborative style of innovation process.
- The innovation models continue to evolve after the 5th generation. Examples of new models are internet-platform business and big data/predictive analytics.

Different generations will require different resources and participants, and thus different measurement systems. The 4th and 5th generations are likely to involve different participants along the value delivery chain and those participants may include customers, suppliers, peer companies, universities, and the general public (for crowd sourcing), and thus need multi-dimensional measurement frameworks. As we dive deeper into measurement frameworks, it is useful to tie the frameworks with the different generations of innovations and realize that many metrics in use are not complicated enough to capture the 4th and 5th generation of innovation models.

Figure 2: The Evolution of Innovation Models



Source: Based on Rothwell (1994).

Part II: A review of innovation models used in measurement of innovation activity

As the thinking on innovation models evolved from the 1st to the 5th generation, it led to different measurement approaches.

2.1 Country level

Over decades, several scholars and organizations have developed measurement models of innovation at the country level, so that governments can create informed innovation policies and cultivate a friendly environment to promote economic growth and development. Those types of measurements focus on the economic, market and institutional environment with regard to innovation, instead of the detailed processes of innovation management within companies. The business process of innovation is mostly treated as a black box at this level.

At the macro level, measurement models have evolved with the 5 generations of innovation processes from the 1950s to the present (Milbergs and Vonortas, 2004). Macro measurement models in the 1950s and 1960s focused on inputs such as R&D spending, science & technology personnel, and education attainment, and in the 1970s and 1980s began to include intermediate inputs of innovation such as “patents, publications, products and quality

change,” both to measure the linear Technology Push Model (1st generation). During the 1990s, the country level metrics led to the development of innovation indexes and ranks and benchmarks countries on their innovation capability, covering innovation processes of the 1st to the 4th generations.

In the 2000s, measurement efforts have begun to treat innovation as a complex system rather than a strictly linear process. Though still in nascence, it measures “knowledge, intangibles, networks, demand, clusters, management techniques, risk/return and system dynamics” (Milbergs and Vonortas, 2004), which are components of the 5th generation of innovation processes. Moreover, a beginning was made with combining metrics at the country level with those at the company level. An important transition away from perceiving innovation as a linear process was the literature on National Innovation System (NIS), developed by scholars such as Freeman (1987), Lundvall (1992), Nelson (1993) and later implemented by the OECD (1997), mapping the knowledge flows in a country.

The Oslo Framework

The most influential innovation measurement frameworks are the Frascati Manual of the OECD which has provided guidelines of measuring R&D in countries since the 1960s and the Oslo Manual of the OECD that guides the innovation surveys in over 80 countries since the 1990s (OECD, 2015). The Oslo Manual proposes a measurement framework that includes the firm as part of an innovation system (Figure 3). The firm carries out four types of innovations—product, process, marketing and organizational structures. The innovation system that impacts the firm includes demand, other firms, education and public research system, innovation policies, and infrastructure and institutions. Under that framework, the Community Innovation Survey of the EU measures 7 types of innovation activities for product and process innovations:

- Intramural (in-house) R&D
- Acquisition of R&D
- Acquisition of other external knowledge
- Acquisition of machinery, equipment and other capital goods
- Other preparations for product and process innovations
- Market preparations for product innovations, and
- Training

About 80 countries have now adopted the Oslo framework and carry out innovation surveys along those lines (Hollanders, 2008).

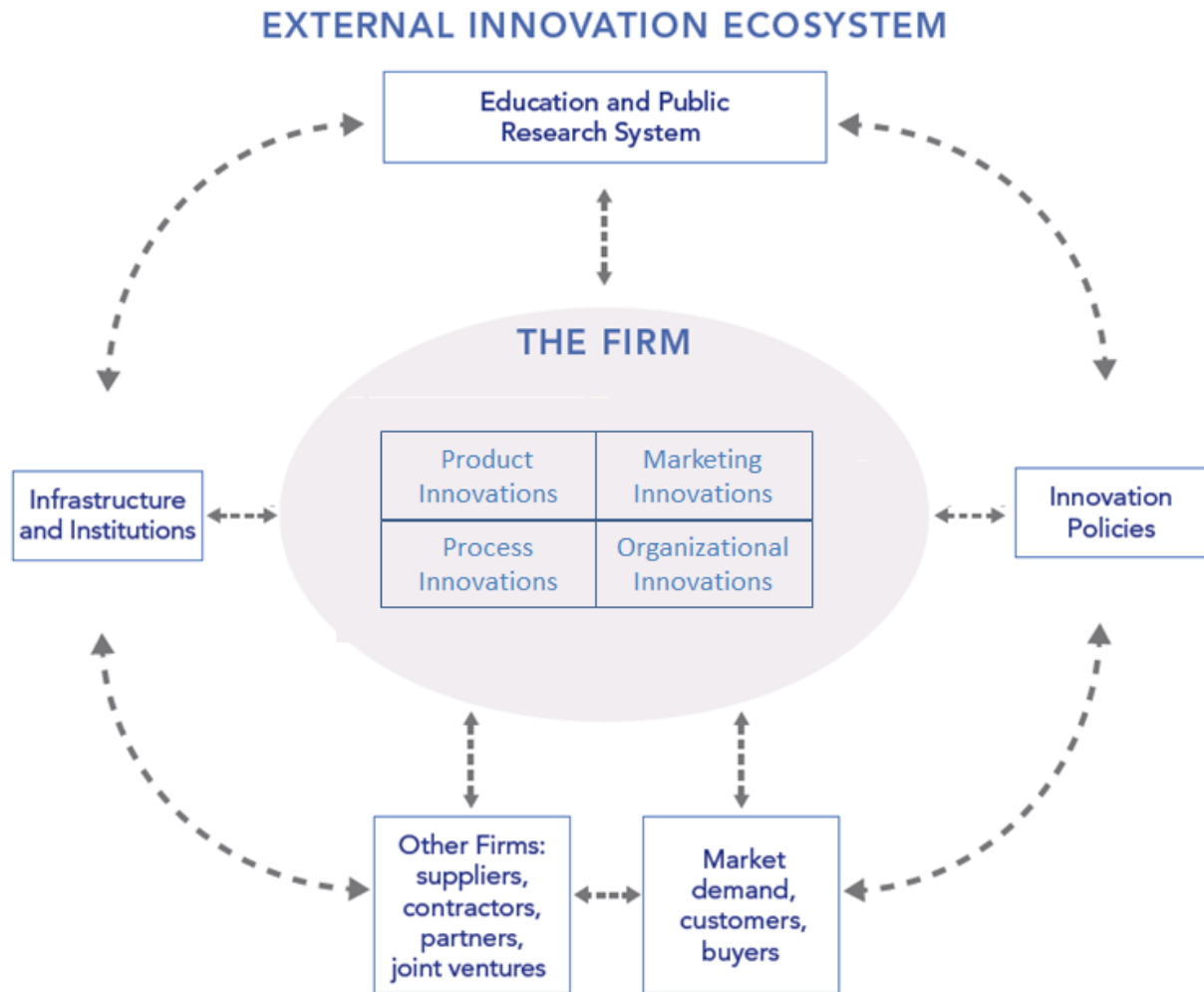
National Innovation System (NIS)

The NIS approach stresses the knowledge flows among people, companies and institutions in the innovation process (OECD, 1997). Under this framework, OECD suggests that countries measure four types of knowledge flows:

- Flows among companies
- Flows among companies, universities and public research institutions
- Diffusion to companies, including diffusion through machines and equipment, and
- Mobility of technical personnel within and between the private and public sectors

The OECD has also suggested possible ways such as firm surveys and cluster analysis to collect data on and analyze the NIS. Possibly because the NIS is complex, there is no integrated cross-country dataset based on this framework available as yet, but the OECD issues reports on the NIS’ of some individual countries. However, the OECD approach to NIS is still biased toward technology and R&D while successful innovations require broader skills.

Figure 3: Framework for Innovation Measurement According to the Oslo Manual



Source: Based on OECD, 2005

2.2 Company level

Measurement of innovation within companies is not widely shared in the research field, and there is therefore little guidance towards framing the “black box” of the innovation processes. Depending on how a researcher/practitioner understands the innovation process, he or she may suggest different models. In this section we discuss various models that could underlie innovation measurement at the company level, making a distinction between linear models and more complex models with feedback loops. We also distinguish between models with multiple simultaneous innovation processes and those that focus on a single dimension of innovation, such as the flow of ideas.

Finding a consistent measurement framework applicable to a wide range of companies still has a long way to go. There is no present-day assessment of how widely accepted and how applicable a company-level models of innovation are, and ideas about innovation measurement are highly variable. This project aims to provide more structure to this debate in order to develop a flexible system of innovation metrics which should guide companies in developing their own system of innovation metrics.

The Diamond Model

The Diamond Model by Tidd et al (2005) follows the 4th and 5th generations of innovation processes, assessing the resources and the potential of innovation initiatives. It measures five dimensions of a company—strategy, process, organization, linkages and learning (Figure 4), which can be applied to companies with simple linear innovation processes as well as companies with complex open innovation processes:

- The **strategy dimension** includes the strategic planning process, the priority of innovation strategy, and the implementation of the strategy;
- The **process dimension** includes internal process management, the process of new product development, and integration of customers' needs into the process;
- The **organization dimension** measures the communication of innovative ideas;
- The **linkage dimension** measures the relationship with suppliers, customers, universities and so on;
- The **learning dimension** measures employee training, learning through linkages, learning from success and failures and communications about those learnings.

Figure 4: Measurement Framework—the Diamond Model



Source: Based on Tidd, J., Bessant, J., Pavitt, K., Managing innovation: integrating technological, market and organizational change. Wiley. 2005.

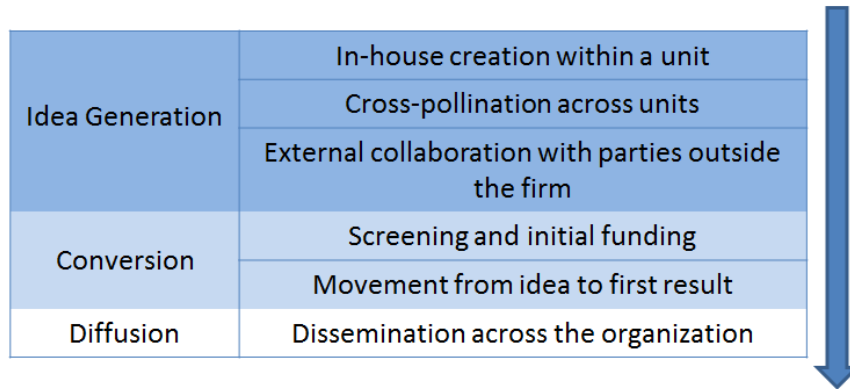
Idea Management Model

Other company-level innovation models are primarily focused on innovation as a process that can be viewed as the management of ideas. Hansen and Birkinshaw (2007) suggest a simple 3-phase framework of idea management to measure innovations (Figure 5). The three phases are idea generation, conversion and diffusion:

- Idea generation includes ideas created within a unit, created from collaboration across units, or created from outside of the firm.
- Idea conversion includes selection and development.
- Idea diffusion is the dissemination across the organization.

The authors recommend some key questions and key performance indicators for each item under the three phases. The three-phase framework may develop into a more complex innovation funnel model.

Figure 5: Measurement Framework—Three-Phase Idea Management



Source: Based on Hansen and Birkinshaw (2007)

Innovation Funnel Model

Morris (2008) proposes a measurement framework of Innovation Funnel along which companies develop innovation ideas/projects, eliminate less-promising ideas/projects along the process, and bring the rest of ideas/projects into successful innovations (Figure 6). He lists the timeline of 9 stages of innovation. The 9 stages are strategic thinking, portfolio management and metrics, research, ideation, insight, targeting, innovation development, market development and sales. He recommends lists of qualitative and quantitative metrics that can be used to measure each of the innovation stage.

Linear models are easier to implement than complex flow and feedback models, but we need to judge them on their merits. Linear models view innovation as a sequential process, and allow companies to manage innovation using a gate system, where a gate keeper decides if an innovation project can move to the next phase or be terminated. The gate system tightly controls the development of an innovation project and it is relatively safe for innovation beginners, but it takes a long time for an innovation project to move from one gate to another. It is suitable for incremental innovations, but not radical innovations. It cannot sufficiently manage the complex and dynamic processes of the 4th and 5th generations.

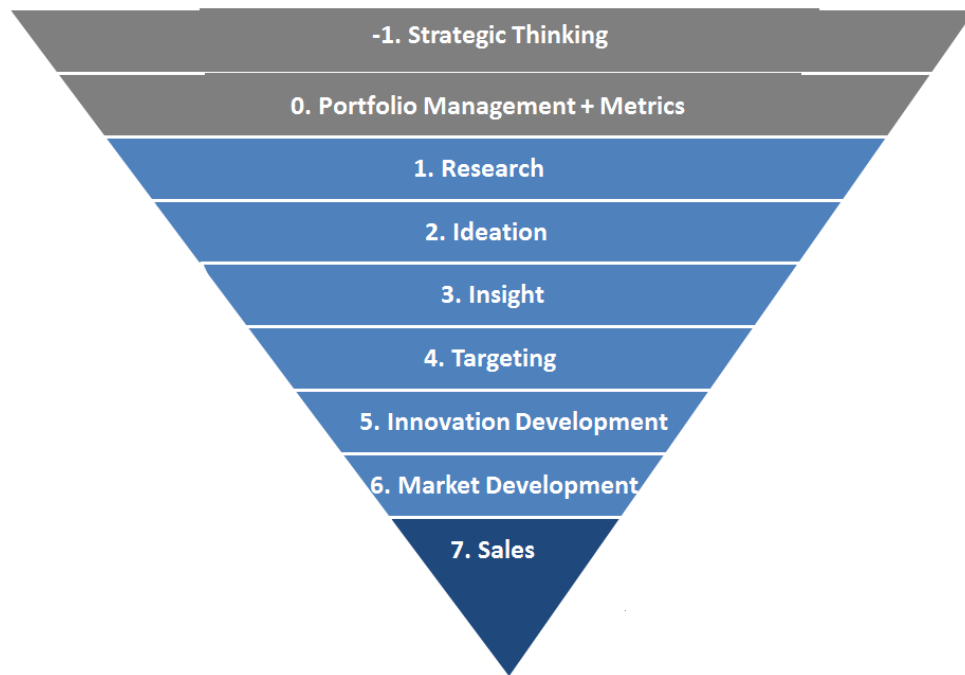
The Model of “Ten Types of Innovations”

In contrast to linear models, Keeley et. al. (2013) argues that ten types of innovations are likely to happen simultaneously along the value delivery system. This may be a more realistic depiction of how innovations tend to occur in a complex innovation ecosystem of today’s business. Further, they argue that innovations regarded as exceptional (e.g. iPhone, iPod, Uber, Amazon) are based on multiple types of innovations, instead of relying on just one or two features. This makes today’s innovations less vulnerable to competition. Ten types of innovations are classified under three segments of the value delivery system (Figure 7):

- “Configuration” segment: innovations on (1) profit model, (2) network, (3) structure, and (4) process;
- “Offering” segment: innovations on (5) product performance and (6) product system;
- “Experience” segment: innovations on (7) service, (8) channel, (9) brand, and (10) customer engagement.

Indeed, in several industries, for example the IT industry, competition is not just about product innovation but about the competition of innovation ecosystems which taps into various types of innovations simultaneously. The Model of Ten Types of Innovation is consistent with our approach of identifying signposts of innovation as major dimensions or categories of innovation activity. A single innovation type or signpost cannot sufficiently span the rich and complex set of activities that characterize innovations.

Figure 6: Measurement Framework—the Innovation Funnel



Source: Based on Morris (2008)

Figure 7: The Ten Types of Innovations

Configuration	1. Profit Model
	2. Network
	3. Structure
	4. Process
Offering	5. Product Performance
	6. Product System
Experience	7. Service
	8. Channel
	9. Brand
	10. Customer Engagement

Source: Based on Keeley et. al (2013)

The Model of Dulkeith and Schepurek (2012)

The Model of Ten Types of Innovations and the Diamond Model are complementary to the idea management models, discussed above. Dulkeith and Schepurek (2012) suggests a framework that combines idea management with innovation strategy and possibly different types of innovations classified into inputs, innovation process, outputs, all measured with a system of key performance indicators (Figure 8). They provide a list of key performance indicators (KPI) for each dimension, and evaluates the effectiveness of each KPI. For example, in idea management, the KPI of “number of high-quality ideas generated within a unit” is evaluated as “very

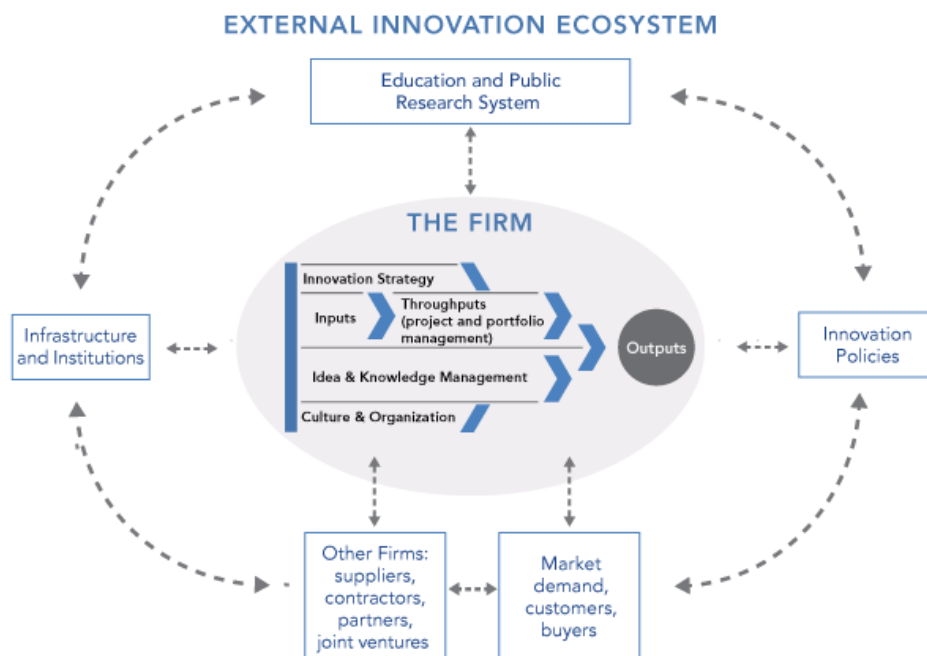
beneficial”, while “average time from idea submission to feedback” is evaluated as “difficult because of feedback responsibility issues”. Because the Dulkeith and Schepurek (2012) model captures the complexity of innovation activities and the layers of innovation strategy and idea management, we adopt and adapt their model to describe innovation within a company, and combine it with the macro-level Oslo framework which is focused on the external business environment (Figure 9).

Figure 8: Measurement Framework at the Firm Level



Source: Dulkeith and Schepurek (2012)

Figure 9: Our framework combines the Oslo framework with the Dulkeith and Schepurek (2012) framework



Sources: Oslo Manual, OECD (2005), Dulkeith and Schepurek (2012), and The Conference Board.

2.3 Industry level

Innovation metrics at industry-level are in practice either a breakdown of country-level indexes, or a summary of company-level measures. The goals of industry indexes are to identify heterogeneity across industries at the macro level, or among companies to rank them and build industry benchmarks, or to present industry trends. We will dive into existing industry indexes in the following section.

Part III: A review of existing measures of innovation

There is a gap between frameworks or models of innovation and the practice of measuring innovations because of a lack of data, especially at the company level. In this section we review the major indexes of innovations at the country level, and summarize some of the attempts of measuring innovations at the company level and at the industry level. We do not claim this to be an exhaustive review of all existing metrics. Instead we aim to identify the most common practices of innovation measurement.

3.1 Country-level indexes

3.1.1 Five country (or regional) indexes of innovations

There are various innovation-related indexes at the country level or at the regional level. We review five major indexes for their structures and variables. The 5 indexes are (see Text Box 1):

- *The Global Innovation Index*, (GII) provided by the World Intellectual Property Organization of the United Nations
- *The European Innovation Scoreboard*, (EIS) provided by the European Commission
- *The Global Creativity Index*, (GCI) provided by Martin Prosperity Institute
- *The Global Entrepreneurship Index*, (GEI) provided by the Global Entrepreneurship and Development Institute, and
- *The Portfolio Innovation Index (PII)* on US states and counties provided by Indiana University's Kelley School of Business supported by the U.S. Development Administration.

The five composite indexes use different variables to measure innovation. The GII uses 79 variables (Global Innovation Index, 2015), the GEI uses 31 variables, the EIS uses 30 variables (European Innovation Index, 2009), the GCI uses six variables, and the PII uses 15 variables. The first four indexes are at the country level, and the last index is at the regional level of the United States.

They are quite representative of how innovation-related indexes are constructed at the macro level. All five indexes are composite indexes of sets of macro variables measuring the enablers (e.g. human resources), firm activities (e.g. R&D spending) and outputs (e.g. sales of new products). Under the category of enablers, there are groups of variables measuring human capital, institutions, infrastructure, market, and business sophistications. Under the category of firm activities, there are groups of variables measuring firm investments, linkages & entrepreneurship, patents, trademarks and designs. Under the category of outputs, there are variables measuring product and process innovations, creative goods and services, employment growth, GDP growth, and so on.

3.1.2 An assessment of country-level indexes

Policy makers tend to focus on input measures, while companies emphasize output measures. Boston Consulting Group (2006) found out that business executives ranked time to market, sales from new product and return on investment of innovation as the top three measures of innovation. In contrast, macro indexes use many input metrics partly because input data are easier to find than output data.

Country level macroeconomic innovation indexes have a number of shortcomings regarding their use by policy makers:

1) **They cannot sufficiently capture the rapidly changing innovation models at the company level** (Hollanders and van Cruysen, 2008). In the 1950s and 1960s, the major types of innovations were R&D based, and in the 1980s the model of user innovation became important where consumers/users shaped new innovations, and then came the model of open innovations where companies need to rely heavily on external sources of knowledge. The current macro-level measurement frameworks are still biased toward the R&D-based innovation models typically in the manufacturing sector, and those frameworks insufficiently measure the marketing and organizational innovations and the combinations of different types of innovations along the value delivery chain.

2) **A simple ranking of countries based on their innovation capabilities does not sufficiently capture the complexity of innovation activities.** A composite index summarizes the innovation performance of a country. It

makes a complex situation easier to understand, potentially motivates policy makers to improve on a country's ranking, and could provide a direction for action in policy making. At the same time, a composite index may be too simplistic in describing the heterogeneous process of innovation and may mislead policy makers in their judgement of innovation performance, and for dimensions where data is hard to collect, the composite index ignores those dimensions and that may lead to biased policies (Saisana, 2004 and Nardo et al, 2005).

3) Macro indexes focus on input metrics rather than output metrics due to the availability and maturity of data. For example, even if theoretically EIS should put equal emphasis on input and output metrics, input metrics are overrepresented in the current EIS. Further the EIS does not have throughput metrics to track the innovation process.

4) Macro indexes of innovation are often not timely. The release of country-level measures is usually delayed for several years due to data availability. That makes the measures less useful for governments to make timely policies.

5) Country-specific measures fail to capture the interaction between and among countries. Some countries tend to be sources of innovation, while other countries contribute to other aspects of innovation or are lesser contributors.

Despite their shortcomings, macro-level indicators of innovation could still provide useful guidance to business from the perspective of competitive advantages especially with regard to the comparative strengths of innovation systems (external innovation ecosystems), one of the selected signposts of innovation for this project. Moreover, the problems with macro indexes could shed light on possible problems at the company level if companies rely too heavily on one segment of the innovation process (i.e. outputs) or suffer from data unavailability. Finally, country of origin could be an indicator that a company is advantaged if it is based in a country that is strong with innovations.

Box 1: Five country (or regional) indexes of innovations

The Global Innovation Index (GII) is co-published by Cornell University, INSEAD, and the World Intellectual Property Organization. The GII index has two sub-indexes—the Innovation Input Sub-Index and the Innovation Output Sub-index. The Input Sub-Index covers institutions, human capital and research, infrastructure, market sophistication, and business sophistication. The Output Sub-Index covers creative outputs and knowledge and technology outputs. The GII index is a simple average of the Input and Output Sub-Indexes with each sub-index constructed as a simple average of its component variables. The GII uses data from over 30 sources and does not carry out surveys of its own. Since the first version of GII in 2008, there have been 8 years of this annual index, but it cannot be treated as a continuous time series (Global Innovation Index, 2015).

The European Innovation Scoreboard (EIS) is constructed by the European Commission under the EU Lisbon Strategy. It was first published in 2001. It aims to compare the innovation performance of 27 EU member countries. The scoreboard provides the Summary Innovation Index (a composite index) that gives an overview of innovation performance at the country level. Under that index, there are three building blocks—Enablers, Firm Activities, and Outputs. Enablers include human resources and finance and support; Firm Activities include firm investments, linkages & entrepreneurship, and throughputs; Outputs include innovators and economic effects. The EIS uses 30 variables from various data sources, and does not carry out surveys of its own (European Innovation Scoreboard, 2009).

Box 1 (Continued)

The Global Creativity Index (GCI) is constructed by Martin Prosperity Institute. The GCI 2015 is the earliest version we can find, so it is possible that the GCI was first released in 2015. The GCI measures creativity of 139 countries based on 3 pillars—technology, talent and tolerance. Technology includes R&D spending and the number of patents; talent includes employment in creative occupations; educational attainment; and tolerance includes that toward minorities and gays and lesbians. The index is a composite index of the ranking of its sub-indexes. GCI uses data on 6 variables from public sources and does not carry out surveys of its own.

The Global Entrepreneurship Index (GEI) was constructed by the Global Entrepreneurship and Development Institute. The GEI aims to measure the entrepreneurship process in 130 countries. The index is based on three pillars—entrepreneurial attitudes, abilities, and aspirations. It uses both individual data and macro data (or institutional data) in order to combine the micro- and macro- aspects of entrepreneurship. GEI uses 16 institutional variables from various data sources and 15 individual variables from the GEM survey (GEI has its own survey). GEI is a composite index with the method of penalizing bottlenecks of entrepreneurship. GEI reports are available since 2014 (we cannot find reports before 2014).

Those indexes use data from various public sources. Major data sources on education, employment and patents are official statistics provided by Eurostat or UNESCO Institute for Statistics; sources on Information and Communication Technology (ICT) are ITU World Telecommunication/ICT Indicators Database of the International Telecommunication Union and the Executive Opinion Survey of the World Economic Forum; sources on institutions, infrastructure and market sophistication are Eurostat, World Development Indicators of the World Bank, and the Executive Opinion Survey of the World Economic Forum; sources on firm activities are the Community Innovation Survey provided by Eurostat, and the Executive Opinion Survey of the World Economic Forum.

The Portfolio Innovation Index (PII) is constructed by Indiana University's Kelley School of Business supported by the U.S. Development Administration. The index aims to help regional practitioners identify the strength and weakness of the innovation performance of US states and counties. The PII has 4 pillars—human capital, economic dynamics, productivity and employment, and economic well-being. The PII index is a weighted average of the 4 pillars. Human capital includes education, population growth, occupation mix of the “Creative Class”, and high-tech employment; economic dynamics include R&D investment, venture capital investment, broadband density, churn of firms, and business size; productivity and employment include high-tech employment, job growth, patents and GDP; economic well-being includes net migration and compensation. It is not for a particular year, and rather some of its components are calculated using variables of several years depending on the data availability for the average, or sum, etc. Major data sources of PII are Moody's, US Census, and the Bureau of Economic Analysis of the U.S (The Portfolio Innovation Index, 2006).

GII, and EIS and PII somewhat agree with each other about what are inputs to innovations, while they differ in the concepts of outputs, and EIS is the only index that identifies throughputs. GII measures inputs with the sub-indexes of institutions, human capital and research, infrastructure, market sophistication and business sophistication; EIS measures inputs with human resources, finance and support, firm investments, and linkages & entrepreneurship; PII measures inputs with human capital and economic dynamics. As to outputs, PII identifies GDP, employment and compensation and patents as outputs (the first three are the usual policy goals of the local governments), while the EIS identifies innovations, revenues from innovations and high-tech industries, and high-tech employment as the outputs. The GII identifies a wide list of variables as outputs including for example both GDP and patents.

3.2 Company-level measures

3.2.1 Existing measures

The Community Innovation Surveys

Official statistical agencies in about 80 countries administer innovation surveys to companies mainly following the design of the Community Innovation Surveys (CIS) and the framework of the Oslo Manual (López-Bassols, 2011). In addition to the EU countries, examples of other countries that carry out innovation surveys are Japan, Australia, China, Russia, Brazil, and Mexico (López-Bassols, 2011). CIS surveys collect data mostly on product and process innovations on four major aspects—innovation expenditure, sources of information, effects of innovation, and factors hampering innovations (OECD, 2006). The variables of CIS include share of sales from new products and services by different levels of innovativeness (new to the firm or new to the market), spending on R&D, spending on machines, equipment and software, spending on other external knowledge, importance of different types of information sources, degree of different innovation effects, and degrees of factors hampering innovations. As to marketing and organizational innovations, CIS only identifies whether a company carries out those innovations without collecting further data on expenditure.

Surveys by consulting firms

In addition to official statistical agencies, consulting firms collect data on innovation activities. Consulting firms often do not release the list of variables, the data, or the design of the surveys in each year, so we do not know if the surveys are of a time series or of different themes each year. Moreover, innovation surveys have often not been carried out for multiple years, so there is not a continuous history needed for longitudinal analysis. The examples of those surveys are McKinsey Global Surveys on Innovations, Global surveys of Boston Consulting Group, and Technology Innovation Survey of KPMG (See Text Box 2).

Consulting and research firms sometimes also provide rankings of companies. An example is the list of Most Innovative Companies provided by Fast Company.⁴ Those rankings are good efforts in general but less useful for our purposes, because the list of companies in the top, say, 50 changes every year and are not time series of companies.⁵ More importantly, rankings are backward looking and do not provide direct link to what a company needs to do to innovate.

Various organizations collect detailed time-series data on a single aspect of innovation. For example, for employee engagement, Glassdoor provides reviews of employees of a large number of companies on their employers about culture & values, work/life balance, senior management, compensation & benefits and career opportunities. For brand equity, CoreBrand (now Tenet Partners) collects data on familiarity of a corporate brand, overall reputation, and the power of corporate brands of US companies. For customer satisfaction, the American Customer Satisfaction Index provides data on customer satisfaction for household products and services of 43 industries in the U.S.. For innovation culture, Dobni and Nelson (2012) surveyed Fortune 1000 companies on their innovation culture, including Innovation Intent (Context), Innovation Infrastructure (Resources), Innovation Influence (Knowledge Management), and Innovation Implementation (Execution).

Internal company surveys

In addition to consulting and research firms, companies collect data on different aspects of innovations internally, but information from different aspects are often not integrated to provide a holistic view. Examples are employee engagement surveys carried out periodically in US companies, and the percent of sales from new product and services estimated by the accounting department of a company.

⁴ https://www.fastcompany.com/most-innovative-companies?utm_source=newnavbar&utm_medium=web&utm_campaign=mic

⁵ https://www.fastcompany.com/most-innovative-companies?utm_source=newnavbar&utm_medium=web&utm_campaign=mic

Box 2: Three Examples of Company Measures

Global surveys of McKinsey: McKinsey issues reports on company innovations each year using data from its global surveys. Because McKinsey does not provide a list of survey variables, we do not know the structure and consistency of the surveys over the years. Their reports on innovations seem to cover a different theme each year. In a 2008 survey, McKinsey collects data on innovation priority in business strategy, types of innovations being measured, output measures of innovations, usefulness of innovation measures, and factors determining the allocation of innovation money, while in a 2010 survey, McKinsey collects data on the effectiveness of innovation tactics, innovation priorities, and idea management and commercialization (McKinsey, 2010).

Global surveys of Boston Consulting Group (BCG): BCG carries out an annual survey starting 2008 on innovations across countries, industries and business functions. For example, in 2010, BCG collects data on innovation priority among business strategy, innovation spending, the rate of return, drivers of innovation in the top management, innovation metrics, and innovation hurdles. BCG does not provide the list of variables in its surveys in each year.

Technology Innovation Survey of KPMG: This global survey collects data on barriers to commercialize digital innovation, business functions driving innovations, business functions identifying and nurturing innovations, innovation metrics, innovation incentives, factors enabling innovations within a company, and topics related to specific types of digital innovations (KPMG, 2013).

3.2.2 Caveats on using company-level measures

1) **Overall, companies do not have a wide range of innovation measures readily available.** McKinsey carries out a global survey in 2008 on innovation metrics used by companies (McKinsey, 2008). The survey shows a lack of measurement—out of the 1075 respondents, 51 percent of them indicate that their organizations pursue business model innovations, but only 28 percent of them say that their organizations formally assess the innovation. The patterns are similar for process innovation (61 percent vs. 37 percent), service innovation (65 percent vs. 37 percent), and production innovation (71 percent vs. 54 percent).

2) **Companies do not measure the entire life cycle of innovation.** Companies are more likely to use measures of innovation outputs than inputs (McKinsey, 2008). A shortcoming of output measures is that they are usually lagged and cannot provide timely information on on-going innovation projects. As such they could be useful for evaluation or assessment of existing efforts but they are silent on future activity without further analysis (especially because in the world of innovation past performance is no guarantee of future success). Cordero (1990) reviews innovation measures in firms and finds that firms measure resources (for example, R&D spending) and outputs (for example, market share of new products), but tend to ignore the intermediates in the innovation process (Cordero, 1990).

3) **Measuring innovation in a too strict manner can in fact impede the process of innovation, especially if the focus is on output measures.** Morris (2008) warns that if we define innovation as discovering the unknown, and if we try to pin down unknowns too fast, we are likely to “measure the wrong things at the wrong time,” and that hurts learning, discovery and risk-taking of the innovation process. Morris (2008) uses rate of return (ROI) as an example to warn readers about the danger of innovation measurement impeding the innovation process. For example, ROI works better for short-term innovations and tends to exclude long-term innovations and breakthroughs. “Premature use of ROI to measure innovation thus endangers the very thing you want to measure, and makes less likely to achieve the end goal of the process...” A researcher likely does not know the potential market value of his or her innovation. And if he or she is asked to be responsible for the future ROI, he/her may abandon the innovation for the sake of his or her performance review. The VP of Global Innovation of McCain Food, Sue Jefferson, says that companies must “remove any metrics that are affecting the innovation process detrimentally. The KPIs which a company chooses are inherently linked to the way it defines progress, and its culture.” Jefferson (2015) correctly points out that choosing the right set of metrics is the key in developing innovation metrics for a specific company.

3.3 Industry level measures

Even though we are not listing theoretical frameworks for the industry-level metrics, we would like to emphasize the importance of industry-level measurement, mostly because they are pragmatic when industries differ vastly in the types and forms of innovations. For example, while manufacturing companies usually are able to measure sales from new products, business service companies find it hard to break down sales from new and existing products (Adams et. al., 2008). As a result of industry difference, Adams et. al. (2008) examine innovation metrics for 12 UK sectors and end up listing different sets of innovation metrics for different sectors.

Industry-level indexes are either a breakdown of country-level indexes or an aggregation of company-level indexes. Industry innovation metrics derived from the macro-level metrics enable economists to compare innovation activities across industries, using the same set of metrics for different industries such as the pharmaceutical industry and the banking industry. In contrast, the industry metrics derived from company-level metrics emphasize the industry heterogeneity and propose different metrics for different industries, and sometimes covers only a single industry, so the metrics are pragmatic enough for executives to derive operational business strategies, but are not ideal for cross-industry comparison.

Some examples of industry-level indexes are the Service Sector Innovation Index, the NESTA Innovation Index, the Productive Innovation Index of the Pharmaceutical Industry, and the Elastic Innovation Index of the Financial Services (See Text Box 3).

Box 3: Four Industry Level Innovation Indexes

Service Sector Innovation Index. When an industry index is derived from a national index, its component variables are the same across industries and allow comparability across industries and countries. An example is the Service Sector Innovation Index. It uses data from Community Innovation Survey and covers nine themes for 17 countries:

- Human resources
- Innovation demand
- Public support for innovation
- Inputs to product and process innovation
- Outputs of product and process innovation inputs
- Inputs of non-technological innovation
- Outputs of non-technological innovation
- Outputs of commercialization
- Outputs of intellectual property

The producers of the index acknowledge that the data cannot cover “new business models/concepts,” “new customer/delivery interfaces,” and “new service-product offerings.” (Hollanders, 2008)

This Service Sector Innovation Index allows researchers to compare innovation activities across manufacturing and service sectors, and across countries (the manufacturing index is calculated using the data of the Community Innovation Survey, too). A result of the index is the ranking of 17 countries on their input and output intensity of innovations by sectors. In addition, a finding is that countries weak with innovation in general may do well in service sector innovation, possibly because the innovation in manufacturing sector relies more on knowledge and knowhow, while the innovation in the service sector relies more on catching up of best practices. There is only one year of the index available, and that version uses data from Community Innovation Survey 4 which covers innovation activities of firms between 2002 and 2004.

Box 3 (Continued)

NESTA Innovation Index. The National Endowment for Science Technology and the Arts (NESTA) has carried out research on innovation measurement at the industry level. In our review of industry-level innovation indexes, NESTA's research is the only research and index that bridges the macro and company perspectives. As a preparation for building the index, NESTA sponsors a research paper that reviews the existing firm-level metrics in twelve UK industries, and the researchers propose different sets of metrics for different industries.

NESTA carries out a survey of 1,500 companies across 9 sectors, and develops an Innovation Index for each sector. The NESTA Innovation Index preserves both the comparability of performance across sectors (typical of macro-level indexes) and the sector heterogeneity that allows executives to draw business strategies (typical of company-level indexes). The NESTA survey examines innovations in some fields in more detail than the Community Innovation Survey does, because the NESTA survey asks companies about innovation activities by three stages (accessing knowledge, building innovation, and commercializing innovation), and asks sector-specific questions, while the CIS do not differentiate activities by its stage in innovation process and it uses the same survey questions for all sectors.

The main result of the NESTA Innovation Index is to present the relative innovation performance of each industry by the three innovation stages, and also by the variance of firm performance within a certain sector. A below-average performance of a sector signals a potential opportunity to catch up with other industries, and a high variance of performance of firms within a certain industries indicates opportunities for firms to learn from each other. For example, the NESTA Innovation Index implies that the energy sector is strong in creating innovations, but is not as effective at commercializing them, and firms within that sector can learn a lot from each other on accessing knowledge and commercializing innovation.

Productive Innovation Index of the Pharmaceutical Industry. IDEA Pharma has been releasing an annual index from 2011 to 2016. The index is actually a simple ranking of the top 30 pharma companies that assesses how effective the top 30 pharma companies in commercializing new products. Component variables for this index are global sales/market capitalization, regulatory efficiency (speed to market, end-of-phase I to launch, and regulatory success ratio), attrition rate in phase III, value proposition, sales versus ostensibly similar molecule, gearing, sales and marketing spend versus turnover, ratio of new product ideas versus 'me-toos', percentage of company sales generated by products launched in the last three to five years, analyst ranking, changes in R&D strategy, research collaborations, company restructuring, and innovative commercialization or sales strategies. IDEA Pharma does not carry out its own surveys and uses publicly available data for this index.

Elastic Innovation Index of the Financial Services. Inntribe produces the Elastic Innovation Index of 2015 to evaluate financial service firms' ability and readiness for innovations in operating models with a focus on digital related operating processes. The report finds that while a few firms are able to innovate effectively, many firms lag behind. By assessing innovation inputs (or capabilities), as opposed to innovation outputs (new products or new services), the Elastic Innovation Index measures capability and readiness to change rather than measuring what has been achieved in the business execution process.

The index uses data from 60 financial service firms on five themes—content of communication, technology platform, leadership related to innovations, strategy, and externalization. Then the researchers rank firms by each theme. They find that the top five qualities of becoming a capable innovative firm are thinking as a platform business, having or planning open APIs, having executives with founder experience, engaging in open-source activities, and making use of externalized skills and labor sources. The rest of the results are the rankings of the 60 companies by different themes.

Part IV: The Conference Board framework for measuring innovation activities

When diverse activities are put under the same umbrella of innovation, how would a company measure and manage those activities in a systematic way with a panoramic view? Our framework of six signposts, which we developed on the basis of the review of existing innovation metrics in this paper, as well as input from a number of innovation leaders at The Conference Board member companies (Appendix: Table 1), is designed to help innovation executives track different aspects and activities of innovation. It captures six key dimensions (signposts) of innovation resources at different stages of innovation, incorporates the complexity of the 4th and 5th generations of innovation processes such as the system of open innovations, and can be used by companies internally to measure all five generations of innovation processes.

The six signposts are

- Technology,
- Digitization,
- Environmental & Social Sustainability,
- Customer Experience & Branding,
- Internal Innovation Networks, and
- External Innovation Ecosystems.

(Detailed description of the six signposts are in Section 4.2.)

The innovation metrics associated with each of the signposts can be positioned along the value delivery chain of that specific signpost (Figure 1). Under each signpost, metrics are classified as inputs, throughputs and outputs. This signpost system is also designed to measure multiple types of innovations along the value delivery chain. Finally, at the center of our innovation signposts we place outcomes because the activities under each signpost are generally expected to contribute to financial and other business performance outcomes.

4.1 Characteristics of signposts of innovation

Before discussing the signposts in more details, we summarize some of the key characteristics of innovation metrics discussed above in Section 3 to guide the selection of signposts and metrics of innovation activities:

1) Positioning metrics along the value delivery chain

We combine the position of each metric along the value delivery chain of that specific signpost, using an input, throughput and output structure (Table 2 and Table 3). In this way, we can track both the resources devoted to innovation activity, and the implementation of innovation initiatives along the lines of the six dimensions. For example, R&D spending leads to patents and licenses and then possibly leads to license revenues. In this case, R&D is an input, a patent is a throughput (intermediates) and facilitates future revenue streams through development and commercialization, and revenues from license fees are an output. We also could track, for example, from the spending on market research to the duration of customer relationship to the share of sales from new customers. And we can track the support from top managers on innovation initiatives, to increase in R&D spending, to the market size increased due to new services.

Crucially, we make a distinction between innovation activity and the resulting possible innovations themselves. The former may or may not lead to new innovations, new markets or new revenue streams. However, more holistically, the process and activity that eventually yields innovation value for the business is what is important and needs to be measured and managed. This also makes room for the idea of measuring and incentivizing failure rates. Our framework is not intended to measure the number of discrete innovations that a company produces; rather it is meant to educate and guide the process by which a company incorporates innovation activity into its goals and strategies to drive value creation.

Table 2: Signposts vs. Input-Throughput-Output (examples)

Signpost	Input	Throughput	Output
Technology	R&D	Patents	Receipts of license fees
Digitization	ICT spending	ICT access index	ICT and business model creation
Environmental & Social Sustainability	Investment in operational sustainability	Number of ISO 14001 environmental certificates	Environmental Performance Index
Customer Experience & Branding	Spending on advertising	Relationship duration	Customer satisfaction
Internal Innovation Networks (leadership & organization, processes & tools, people & skills, and culture & values)	Spending on innovation projects	Number of new ideas created internally	Number of new products developed from new ideas
External Innovation Ecosystems	Venture capital access (links with government, research & education and access to finance)	University/industry collaboration	innovators (% of SMEs)
Profit and Revenues	Innovation budget	potential of entire new product/service portfolio to meet growth targets	% of sales revenues from new products/services

Table 3: Input-Output-Throughput vs. Macro/Company (examples)

	Input	Throughput	Output
Macro	R&D; ICT spending; Venture capital access;	Patents; University/industry collaboration	High-technology exports
Company	Investment in operational sustainability; Spending on innovation projects	Relationship duration; Number of innovation projects	Revenues from new products; Customer satisfaction

2) Treating business innovation as part of the business environment

We provide information on both macro (country and regional) and micro (company) metrics. In today's global economy, a large company tends to operate in different countries, so it is important that a company understands the innovation potential of (or competition from) countries compared to the innovation performance of that company. In addition to country-level data, innovation measures across industries could help a company learn from other industries.

We recognize that innovation is not just about invention, although the latter is sometimes an important ingredient. Invention is primarily oriented towards creating something new, typically a new product or new service. In

contrast, innovation has the more general goal of creating “new” revenues or profits. To make this point clearer, invention usually requires only R&D or other knowhow and is primarily an input measure, while product and services innovations require commercialization and focuses on throughput and output metrics.

Moreover, innovation activities generally require collaboration among and innovations within different business functions of a company. The KPMG Technology Innovation Survey (2013) finds that the top three business functions contributing to innovation are research and development, information technology, and strategic planning, and those business functions are likely to be changed by innovations, too. The survey identifies the top 10 factors that enable technology innovation in companies, implying an even broader list of participants in the innovation process (availability of talent, access to technology infrastructure, ability to drive, ability to drive customer adoption, access to capital, development of disruptive technology, innovation incentives, access to alliances and partnerships, mentoring and access to innovation network, training and education programs, and supporting ecosystem). Those findings are consistent with the model of Ten Types of Innovations (Keeley et. al., 2013), because both imply that innovation requires participants from and innovations in different business functions. Furthermore, innovation activities expand beyond the boundary of a firm. Government policy, population education attainment, maturity of the capital market of a country, and knowledge flows among companies, universities and research institutes can all affect the potential innovation capabilities of a company (OECD, 1997). Some of these factors can be influenced by the firm but many may be completely beyond their control in their external environment.

New forms of innovation and innovation processes evolve over time. The more traditional measures such as those in the Community Innovation Surveys classify innovations into 4 categories—product innovation, process innovation, marketing innovation and organizational innovation. Then new forms of innovations, such as open innovations, cannot necessarily fit into one of the four categories. To capture the new forms, the model of Ten Types of Innovations describes the innovation activities of a company as multiple types of innovations happening at the same time along the value delivery chain in a complex innovation ecosystem where both insiders and outsiders of a company matter greatly for successful innovations.

3) Creating a flexible data structure

We propose a flexible data structure in our proposed framework of signposts of innovation. This flexible structure would allow our member companies to select variables to construct their own innovation indexes, according to their own definitions and their specific types of innovations. Moreover, we encourage companies to select their own set of variables at the country level to zoom in on the aspects relevant to its business. Further, the flexible data structure is meant to adjust to the ever-evolving types of innovations. It is important that we admit that the innovations are about the unknowns and we need to evolve our framework together with the new innovation activities all over the world.

4.2 Overview of the signposts of innovation

Center of the Signpost Framework: Financial Performance

At the center of the signposts is financial performance (see Figure 1). Companies innovate to ultimately increase revenues, raise profits, create shareholder value, or to achieve some other financial or business goals. Thus, financial performance rests at the center of the goals of many innovation activities. Some intermediate innovation goals, such as attracting new customers, accelerate the share of digital products and services, or decrease the environmental footprint of the firm, sometimes can fall within the six signposts. For example, a company with a subscription-based business model may consider new subscriptions as a more important measure of innovation success than the current year profit, especially when the company strives for profit in the long-term. Sometimes, having the reputation of being an innovative company can be a business goal. Hence while being aware that the goals of many businesses engaged in innovation are broader than financial performance, financial performance is still the most important goal for most companies.

In current practice, financial metrics are among the most popular output metrics adopted. KPMG Technology Innovation Survey (2013) finds that the top three measures of the value of an innovation are revenue growth, ROI, and market share. This is consistent with the global survey of McKinsey (2008)—the most important outcome metric is revenue growth due to new products or services. Examples of financial measures are:

- Percent sales from new products/services in given time period,
- Increase in return on equity due to innovation,
- Return on investment in new products or services,
- Potential of entire new product/service portfolio to meet growth targets,
- Changes in market share resulting from new products/services, and
- Net present value of entire new product/service portfolio.

Signpost 1: Technology

Technology metrics are probably the most widely accepted measures of innovation capability at firm and economy-wide levels. It is a traditional measure adopted by governments. R&D spending and the number of scientists are well-known indicators of technology that show up on news headlines.

If we categorize measures by input, throughput and output, R&D spending and number of researchers are inputs, while a patent is a throughput (or an intermediate input). As to the output of research, executives of different industries would have different answers. For instance, an executive from a large pharmaceutical company, one of the people we interviewed, identifies sales from new products as the most important measure of the output of technology, and considers number of patents as inputs. In contrast, an executive from a large IT company identifies the number of patents as the output of technology—an IT company can charge high price to other companies for its licenses.

The importance of technology cannot be overstated for the economy, but its business impact does vary across industries. The pharmaceutical and automobile industries tend to spend heavily on research and development, while the financial industry does not spend much on science and technology and does not employ many scientists. Unlike some manufacturing industries which rely on their R&D departments, service industries tend to use new ideas collected from various business functions, and are less likely to report R&D as a standalone business expense in company annual reports.⁶

Data on measures of technology at the country level are abundant, but are harder to find at the company level. Metrics at the country level are, for example:

- Research & development expenditure,
- Science & Technology (S&T) personnel,
- Patents,
- S&T publications, and
- High-tech exports.

Such measures are available from national official statistics agencies, Eurostat, the United Nations, the World Bank, just to name a few.

Metrics at the company level are similar to those at the country level, for example:

- R&D spending as a percentage of sales from company financial statements,
- Number of patents from national patent offices,
- Other variables, such as the number of ideas or concepts in the pipeline.

⁶ Instead of managing R&D, companies, especially service companies, may choose to manage ideas and treat insights from R&D as one type of idea creation. The definition of ideas is broader than R&D insights. Ideas may include feedback from customers that may lead to new products, or a suggestion from a middle-level manager about improving management efficiency. Measuring ideas (usually across different business functions) is harder than measuring R&D, but some companies find idea management very relevant to the management of innovation process. Hansen and Birkinshaw (2007) suggest a simple 3-phase framework of idea management to measure innovations. The three phases of idea management are idea generation, conversion and diffusion. The idea diffusion and three types of idea generation (in-house, cross-pollination, and external) are quite similar to the different types of knowledge flows identified in the National Innovation System of OECD. So researchers at both the firm-level and macro-level are aware of the importance of managing and tracking the flow of knowledge and ideas.

Data on patents and R&D spending are available from public information sources, but many other metrics are collected internally in a company.

Signpost 2: Digitization

ICT (information and communications technology), Internet and other digital technology/equipment have changed the economy, the business world, and society in many ways, ranging from the consumption of households, to the production of goods and services as well as the social sphere in which people interact. The upcoming waves of digital innovations such as artificial intelligence and the Internet of Things are expected to continue to transform the business world. In two recent studies, The Conference Board (2016a, 2016b), defines Digital Transformation as “The use of digital technologies and the data they produce to connect organizations, people, physical assets, processes, etc., for the purpose of rapidly developing new products, services, markets, and business models to capitalize on emerging customer needs”. Thus, digital transformation is a much broader concept whereas digitization is driven by adoption of mobile technology, ubiquitous access to the internet, the adoption of cloud services and big data and analytics as well as social media and enterprise platforms, artificial intelligence and cognitive computing. It can include use of additive manufacturing or 3D printing. Digitization differs from the broader concept of digital transformation, which concerns the use of digital technologies and the data they produce to connect organizations, people, physical assets, processes, etc. for the purpose of rapidly developing new products, services, markets, and business models to capitalize on emerging customer needs (The Conference Board (2016a, 2016b). In this way, digital transformation spans several signposts, of which digitization is only one, and connects them in a complex web of business interactions.

Digitization can be measured both on the dimension of products/services and on the way of doing things. DigiWorld Yearbook 2015 defines 6 types of products and services as related to digitization—network equipment, IT services & software, telecom services, TV and video services, Internet services, and devices.

We can also define “digital” as a way of doing things (activities). McKinsey (2015) defines “digital” as (1) creating new products and services (e.g. The Internet of Things) and finding new ways to reduce costs (big-data enhance logistics); (2) improving on serving customers (e.g. personalized communications and automation of customer interactions); (3) building an agile organization with processes facilitated by digital technology.

Digitization measures at the country level are plentiful for example:

- IT expenditure (% of GDP),
- Mobile phone subscriptions,
- Fixed telephone lines,
- Number of internet users,
- Internet bandwidth,
- Broadband subscription,
- Government’s online service,
- Software spending,
- ICT and business model creation,
- General top-level domains,
- Video uploads on YouTube.

Data sources are ZookNIC, Google, Wikimedia Foundation, ITU World Telecommunication/ICT Indicators Database of the International Telecommunication Union, and the Executive Opinion Survey of the World Economic Forum.⁷

Data on digitization at the company-level are rarely collected across companies, but there are still a few data sources. The executive Opinion Survey of the World Economic Forum collected data on ICTs and business model creation, and ICTs and organizational model creation. McKinsey carries out global surveys on digital transformation. For example, a McKinsey report in 2013 lists survey results such as the degree to which companies carry out different types of digital innovations (McKinsey, 2013).

Digitization measures at the company level are, for example:

⁷ For data sources of the metrics of the six signposts, please see our meta-database of innovation metrics (upcoming).

- Percentage of documents digitally archived,
- IT spending per employee,
- Ratio between IT staff and all non-IT staff,
- Percentage IT budget of total revenues.

However, several of those measures are not that useful anymore for companies operating in the New Digital Economy, where digitization is driven by a combination of mobile technology; ubiquitous access to the internet; and the shift toward storage, analysis, and development of new applications in the cloud. For example, in this latest wave the role of IT staff is declining relative to the importance of non-IT staff to be tech-savvy and be able to understand and apply digital tools. Also digitization is often happening as part of the other business processes, including sales and marketing, so that IT budgets matter less. We therefore need to move towards an entirely new system of metrics for the New Digital Economy, which will be an important goal in the follow up research in this research project.

Signpost 3: Customer Experience and Branding

Customer experience and branding are two strongly related areas reflecting the importance of how consumers experience, value and even contribute to innovation. These two aspects of innovation are strongly connected as customer relationships are built through experiences with the brand and new products/services under the brand over time. Conversely, an innovative brand has a significant impact on the perception of brands and the anticipated customer experience.

In innovation leaders' minds customer experience is the closest one can get to an output measure on innovation and could replace or at least supplement the common output metric of revenues, according to our interviews with innovation leaders. For example, the subscription business considers customer satisfaction to be more important than one-time revenues, because customer satisfaction creates recurring revenues in the coming years. Incorporating customer experience into the signposts framework stresses the user-centric approach towards innovation.

In recent years, companies have focused even harder on delivering a more relevant and differentiated customer experience through taking a more holistic approach to innovation and leveraging their brand assets. Branding is the sum total of what a company does to communicate and deliver a brand promise, and innovation adds an additional enhancement to that promise. For instance, when a new product is launched by a respected brand, that product has an eager prospective group of customers, predisposed to trying it and buying it. And, when a brand is refreshed through a successful innovation, that innovation makes the brand and customer relationships even stronger. If a company nurtures a culture of innovation, customer experience is expected to be higher than without it.

Finally, customers are not just at the receiving end of a company's innovation. Co-creation of products and services through continuous feedback loops between producers and users are becoming critical elements of the innovation process. Also household innovation outside the business sector is becoming increasingly important, involving as many as between 3 and 6 percent of households in mature economies, such as Canada, the UK and the USA. This new source of innovation could be an important driver of business innovations.

The measures at the company level are mostly available from consulting firms, for example:

- Advertising spending provided by company financial statements,
- Data on brands, such as familiarity of corporate brand, reputation or brand power, and
- Customer satisfaction.

A good example of brand data related to innovation is the brand index of Tenet Partners (previously by CoreBrand). Measures of customer satisfaction are provided by YouGov's, the American Customer Satisfaction Index, and the Temkin Customer Service Ratings.

Measures on customer experience and brands at the country level are, for example:

- Spending on advertisement (% GDP),
- Number of trademark applications,

- Rank of country brands, and
- Degrees of customer orientation and buyer sophistication.

Data sources are FutureBrand, Zenith Optimedia, World Advertising Research Center, the World Development Indicators of the World Bank, and the Executive Opinion Survey of the World Economic Forum.

Signpost 4: Environmental and Social Sustainability

This signpost involves innovation in the pursuit of a business growth strategy that creates long-term shareholder value by seizing opportunities and managing risks related to the company's environmental and social impacts. These impacts include elements of corporate citizenship, corporate governance, environmental stewardship, labor and workplace conditions, supply chain and procurement, community involvement, and philanthropy.

Environmental and social sustainability is often a key target of high performing organizations. These strategies often create new challenges and opportunities for business innovation. To address these challenges, a growing number of companies are embedding sustainability practices into their innovation processes and developing portfolios of sustainability-advantaged products, services, and solutions. Several companies are investing significantly in sustainability R&D and generating sizeable revenues from these innovations. General Electric, for example, in 2015 allocated over half of the company's R&D budget to its Ecomagination initiative. Similarly, Siemens' Environmental Portfolio accounted for 43 percent of the company's overall revenue in 2015.

The measures at the country level include, for example:

- Resource efficiency innovators (% of firms) provided by the Community Innovation Survey (CIS) of EUROSTAT.
- CO2 emissions and other emissions from different sources and alternative and nuclear energy (% of total energy use) provided by the World Development Indicators of the World Bank,
- GDP per unit of energy use provided by the International Energy Agency, and
- The number of ISO 14001 environmental certificates provided by the International Organization for Standardization.

The measures on environmental and social sustainability at the company level include, for example:

- Atmospheric emissions,
- Energy and electricity consumption,
- Water consumption,
- Waste reduction,
- Biodiversity policies.

Some of this raw data can currently be found in company annual reports and/or sustainability reports and also at The Conference Board Sustainability Practices Dashboard (The Conference Board, 2016c).

Signpost 5: Internal Innovation Networks

Internal innovation network is at the core of a business' innovation process. In the 2017 edition of The Conference Board CEO Challenge there is clear recognition that for an organization to achieve innovation success, counter the emergence of new and more nimble competitors, and get ahead of evolving customer demands and needs, it must have a culture that is inclusive, collaborative, and networked. The top four strategies to address the challenge of innovation are all related to internal innovation networks (The Conference Board 2017) :

1. Engage in strategic alliances with customers, suppliers, and/or other business partners
2. Develop managers and leaders to promote idea sharing in teams
3. Establish a strong collaborative culture that encourages cooperation across functions and business units
4. Emphasize creativity and/or innovation as a corporate value or principle.

The internal innovation networks include leadership & organization, processes & tools, people & skills, and culture & values. In a 2010 McKinsey Global Survey, 42 percent of 2,240 executives from different industries, regions and functions identified (1) organization and (2) a climate fostering innovations as the top two challenges to

innovation, followed by commercializing new business, products and services (McKinsey, 2010). More specifically, a company is likely to increase its innovation performance if it sets formal priorities in its planning process and if the company improves on the relationship between R&D and marketing and the process of turning new ideas into prototypes.

As to company-level measures, we use Dobni and Nelson (2012) as an example. Dobni and Nelson (2012) measure internal innovation environment (in our words, internal innovation networks) with four major categories and nineteen detailed types of metrics:

- Innovation Intent (Context), including “Innovation Propensity”, “Employee Connectivity”, and “Strategic Infrastructure”;
- Innovation Infrastructure (Resources), including “Employee Skills & Creativity”, “Organizational Learning”, and “Technical & Financial Support”;
- Innovation Influence (Knowledge Management), including “Business Environment Enactment”, “Industry/Competitor/Client Knowledge Dissemination”, and “Industry/Competitor/Client Knowledge Generation”;
- Innovation Implementation (Execution), including “Alignment”, “New Venture Management”, and “Employee Empowerment”.

As to specific metrics that can be collected by internal surveys, some examples are:

- Sufficient funding for innovations,
- Talent mix,
- Access to information,
- Incentives for innovation success,
- Organizational structures (hierarchical v.s. flat),
- Individual vs. collective decision making,
- Cooperative teams, and
- Leadership involvement in innovation process.

Measures at the country level, as provided by the Executive Opinion Survey of World Economic Forum, are, for example:

- The extent of staff training,
- Nature of competitive advantage,
- Value chain breadth,
- Control of international distribution,
- Production process sophistication,
- Willingness to delegate authority, and
- Capacity for innovation.

Also the Enterprise Surveys of the International Finance Corporation and the World Bank provide information on the number of firms offering formal training.

Signpost 6: External Innovation Ecosystem

Firms do not carry out their innovation activity in a vacuum, and increasingly collaborations beyond the firm boundaries become important. Many external factors determine if firms are able to carry out innovations, how they innovate and what innovations will be operational or come to market. Factors related to the innovation ecosystem include market demand, innovations in other firms, education and public research system, government innovation policy, access to capital, collaborative arrangements with other large and small companies, and infrastructure and institutions frameworks.

Indeed recent competition has started to shift from taking place between firms to occurring between innovation ecosystems, where firms may become more competitive than before by accelerating their paces of innovation in an open and collaborative environment, thanks to globalization, changes in industry boundaries and advances in technologies (Velu, 2010). This means building and nourishing strategic external alliances with customers, suppliers, and business partners while fostering internal, cross-functional and cross-business unit collaboration.

External innovation systems are often geographically determined. Silicon Valley is one of the most well-known examples of an innovation ecosystem. Access to top technology companies, universities, venture capital and a culture of risk tolerance all contribute to making Silicon Valley a cradle of many successful and highly valuable innovations. But there are many other examples of such geographical innovation systems, including Research Triangle in North Carolina, Amsterdam's ArenA Innovation Center in the Netherlands, and Singapore's Research, Innovation and Enterprise (RIEC) council.

In some ways, the measurement of the relationships between a company and the external innovation ecosystem will encompass the previous five signposts. For example, open innovations, an innovation type that relies heavily on an external innovation ecosystem, draw from different types of resources/signposts. In the 4th and 5th generations of innovation models, multiple types of innovations tend to happen simultaneously along different segments of the value delivery chain both inside and outside a firm.

Data on external innovation ecosystems are relatively abundant such as the ease of starting a business provided by the World Bank, the intensity of local competition provided by the Executive Opinion Survey of the World Economic Forum, and public R&D expenditures provided by Eurostat. At the company level, external innovation ecosystems could be characterized by, for example:

- Number of innovation projects with third parties
- Joint funding of innovation expenses with other organizations
- Amount spent on basic research or participation in innovation platforms.

Interaction among Signposts

Signposts could overlap and interact with each other, and they do not stand completely independent of each other. Especially in the 4th and 5th generations of the innovation models, innovations involve participants along the different segments of value delivery chain, where multiple types of innovations (such as product innovations and brand innovations) are required to happen simultaneously (Keeley et. al., 2013). For example, a 2013 McKinsey Global Survey found that the top five types of big-data/analytics tools companies have deployed are impacting different parts of the value delivery chain—"budgeting, forecasting, or planning processes", "performance management and transparency in internal operations", "automation of common or straightforward decisions", "R&D processes" and "operations, service delivery, or supply-chain management" (McKinsey, 2013). Another example is an interaction between sustainability and brands as company practice on sustainability can be an important objective in promoting company reputation.

4.3 Flexible data structure

We propose a data structure where a company can select the variables key to its innovation management and measurement, because innovation metrics vary across industries, companies, or even projects within the same company (Jefferson, 2015).

Goals and strategies differ

Metrics are different when companies have different innovation goals and strategies (McKinsey, 2008). McKinsey carried out a global survey in 2008 on innovation metrics used by companies. The survey finds out that for companies tracking the impact of innovation on shareholder value, their top innovation measures are "revenue growth, customer satisfaction and the percentage of sales from new products or services". In contrast, for companies setting innovation as "the most important strategic priority", their top measures are "customer satisfaction, the number of ideas in the pipeline, and R&D spending as a percentage of sales".

Sectors do innovation differently

Innovation metrics differ across manufacturing and service sectors, because these sectors have different types and different goals of innovations. For example, the goal of a product innovation in a manufacturing firm can be the creation of a new tool, while the goal of an innovation in the service sector is likely to create new interaction or responsibilities among people. The needs of service customers are sometimes more uncertain and unstable than the expected features of machines, so the target of innovation may be more uncertain for innovation in the service sector.

Adams et. al. (2008) extensively reviewed innovation measures by industry and made a proposal for firm-level measures in 12 UK industries. The researchers find that the 12 UK industries reviewed have to use vastly different measures (or “measurement themes” in the authors’ language) because industries differ greatly in their innovations and innovation processes. Adams et. al. (2008) suggest the measurement theme of “financial performance” for 10 out of the 12 industries, “innovativeness” for 9 of the 12 industries, “technological application” for 4 industries, and “reputational enhancement” for 3 industries, and a handful other measurement themes with each of them recommended for 4 or less industries. Indeed, it would be presumptuous to define a single set of measures for even a group of firms (Chapman, O’Mara, Ronchi and Corso, 2001).

Innovation types employed are different

Measuring different types of innovations also require a flexible structure. In some industries it is no longer competition among specific innovations but rather competition of innovation ecosystems, which implies that multiple types of innovations tend to happen simultaneously along the value delivery chain and involve participants both inside and outside a company.

Inputs, throughputs, and outputs are heterogeneous

Companies need flexibility with identifying inputs, throughputs and outputs. One company’s input may be another company’s output of innovations. For example, the churn rate of customers is likely to be an output metric of subscription-based business, because recurring revenues are more important than the revenues of the current period, so the dominant measure of output in current practice—financial metrics—cannot capture the newly emerged model of subscription-based business (Sloat, Year Unknown). In contrast, a pharmaceutical company is likely to use sales from new products (a traditional financial metric) as a metric of innovation, and treats customer relationship as an input to product innovation, according to our interview with an innovation executive of a large US pharma company.

Who is the primary user of innovation metrics

The definitions of inputs, throughputs and outputs may vary depending on who is the primary user of the innovation measures. In the Portfolio Innovation Index of states and counties of the U.S., the supposed users of the index include local and regional development practitioners, and the index evaluates “innovative capacity, innovation outcome and economic progress”. The output variables of that index are policy targets of local governments—GDP, high-tech employment share growth, job growth-to-population growth ratio, patent activity, net migration, and compensation. In contrast, a company is likely to treat those variables of business environment as input variables.

Incremental vs. transformational matters

Companies need different metrics for breakthroughs and incremental innovations, and using just metrics of incremental innovations are likely to kill potential breakthroughs (Angus, 2015).

Part V: Towards Implementing the Signposts of Innovation Framework

The Signposts of Innovation framework presented in this report is based on the notion that a fixed set of innovation metrics will fail to satisfy the needs of companies in different industries or with different innovation goals. Measurement initiatives for innovation need to recognize the multiple dimensions in the innovation process (over different time frames and across different segments of the value delivery chain).

On the basis of this framework, companies can begin identifying the innovation signposts and underlying metrics that are key to their innovation strategies and activities, and present them in, for example, a scorecard or dashboard framework. This can serve as the starting point for a systematic measurement and tracking tool, but also be used in a conversation on what dimensions of innovation are key for the business. Ultimately, these metrics could help improve resource and investment allocation decisions, identify bottlenecks, and allow for better management of innovative activities.

With this framework in hand, The Conference Board is undertaking a series of new activities in the coming year:

1. We are planning to conduct a business survey on selecting top innovation metrics across signposts
2. In addition to existing metrics, which are largely in the public domain, we are identifying new metrics of innovation by leveraging the knowledge of innovation and other business executives.
3. Through partnerships with other research groups, we are conducting surveys to collect new innovation metrics.
4. We are researching a variety of metrics on their strength to explain aspects/facets of innovation and their impact on financial and business performance.
5. We will be analyzing which innovation metrics provide the best insights in the future of innovation success.

The ultimate goal of this project is to develop a series of metrics that can be collected on a continuous basis, and to provide the basis for benchmarking of metrics between companies, as well as against the aggregate performance of sectors, innovation systems, or even macro-levels such as country or region.

Finally, most innovation metrics tell stories about past and current innovation efforts, from which lessons can be learned for future innovation activities. However, some innovation indicators give more insight into the future of innovation success. Strong examples of such indicators are indexes related to innovation culture in which the continuous searching for new innovation opportunities is in the DNA of the organization. In follow-up research we aim to provide more insights in forward looking characteristics of innovation metrics.

References

- Adams, Richard, Andy Neely, Bassil Yaghi, and John Bessant, 2008. Proposal for Measures of Firm-Level Innovation Performance in 12 Sectors of UK Industry, Innovation Index Working Paper prepared for NESTA.
- American Customer Satisfaction Index, 2016. Available at <http://www.theacsi.org/national-economic-indicator/macroeconomic-indicator>
- Angus Richard, 2015. The Structure Barrier. Chief Innovation Officer, Issue 6. Angus Richard is the Head of Innovation at The Innovation Enterprise.
- van Ark, Bart, 2016. StraightTalk® Global Economic Outlook: Bucking the Trend. Overcoming Uncertainty, Shocks, and Disruption with Qualitative Growth, New York.
- van Ark, Bart, Mitchell, Chuck, and Ray Rebecca. 2016. *The Conference Board CEO Challenge® 2016: Building Capability – Seeking Alignment, Agility, and Talent to Innovate and Grow*. The Conference Board.
- van Ark, Bart, Mitchell, Chuck, and Ray Rebecca. 2017. *The Conference Board CEO Challenge® 2017: Leading Through Risk, Opportunity, Disruption, and Transformation*. The Conference Board.
- Boston Consulting Group (2006), Measuring innovation 2006, Boston, MA.
- Chapman, R.L., O'Mara, C.E., Ronchi, S. and Corso, M. (2001), 'Continuous product innovation: a comparison of key elements across different contingency sets', *Measuring Business Excellence*, Vol. 5, No. 3, pp. 16-23.
- Cordero, R. 1990. The measurement of innovation performance in the firm: an overview. *Research Policy*, Vol. 19, pp. 185-192.
- Dance, Jeff (2008). What is Innovation? 30+ definitions lead to one fresh summary. <http://www.freshconsulting.com/what-is-innovation/>
- Dobni, Brooke and W. Thomas Nelson, Jr., 2012. Innovation Nation? Innovation Health inside the Fortune 1000. A Comprehensive Measure Reveals Strengths, Trouble Spots & a Prescription for Improvement. Available at http://www.innovationone.org/wp-content/uploads/2013/12/InnovationNation_F1000_1c.pdf
- Dulkeith, Eric and Schepurek, Steven (2012) . Innovation Performance Measurement. Assessing and driving the innovation performance of companies. Available at <http://www.detecon.com/ru/files/Opinion-Paper-Innovation-Performance-Measurement-2012.pdf>
- DigiWorld Yearbook 2015. IDATE DigiWorld. Available at http://www.idate.org/en/Digiworld-store/DigiWorld-Yearbook-2015_1009.html
- European Innovation Scoreboard 2009. Comparative Analysis of Innovation Performance. Available at <http://aei.pitt.edu/46018/>
- EUROSTAT, 2012. Community Innovation Surveys. Available at <http://ec.europa.eu/eurostat/web/microdata/community-innovation-survey>
- Fast Company, 2016. https://www.fastcompany.com/most-innovative-companies?utm_source=newnavbar&utm_medium=web&utm_campaign=mic
- Freeman, Christopher, 1987. *Technology and Economic Performance: Lessons from Japan*, Pinter, London.
- Global Creativity Index, 2015. Constructed by Martin Prosperity Institute. Available at <http://martinprosperity.org/media/Global-Creativity-Index-2015.pdf>

- Global Entrepreneurship Index, 2016. Constructed by the Global Entrepreneurship and Development Institute. Available at <https://theledi.org/global-entrepreneurship-and-development-index/>
- Global Innovation Index 2015. <https://www.globalinnovationindex.org/content/page/framework/>
- Hansen and Birkinshaw, 2007. The Innovation Value Chain. Harvard Business Review. Available at <https://hbr.org/2007/06/the-innovation-value-chain>
- Hollanders, Hugo, 2008. Measuring Service Innovation: Service Sector Innovation Index. Available at http://www.6cp.net/downloads/2_%20Hollanders.pdf
- Hollanders, Hugo, and Adriana van Cruysen, 2008. Rethinking the European Innovation Scoreboard: A New Methodology for 2008-2010.
- IDEA Pharma, 2016. Productive Innovation Index of the Pharmaceutical Industry. Constructed by. Available at <http://ideapharma.com/uploads/white-papers/Productive-Innovation-Index-2016-White-Paper.pdf>
- Innotribe, 2015. Elastic Innovation Index of the Financial Services 2015. Available at <https://innotribe.com/wp-content/uploads/2015/05/Innotribe-Innovation-in-Financial-Services-The-Elastic-Innovation-Index-Report.pdf>
- Jefferson, Sue, 2015. The Cultural Barrier. Chief Innovation Officer, Issue 6.
- Keeley, Larry, Helen Walters, Ryan Pikkell, Brian Quinn, 2013. Ten Types of Innovation: The Discipline of Building Breakthroughs. Wiley.
- KPMG, 2013. Technology Innovation survey 2013. The changing landscape of disruptive technologies. In addition to firm-level data, this survey also collect data on the business environment in a country in enabling technology innovation, and a country's potential in leading the global technology innovation.
- López-Bassols, Vladimir (2011). Innovation Surveys and indicators: an international perspective and emerging issues. CSO Business Statistics Seminar on Innovation Statistics.
- Lundvall, B-Å. (ed.) (1992). National Innovation Systems: Towards a Theory of Innovation and Interactive Learning, Pinter, London.
- McKinsey, 2008. McKinsey Global Survey Results: Assessing innovation metrics. Available at http://innovbfa.viabloga.com/files/McKinseyQuarterly_assessing_innovation_metrics_oct_2088.pdf
- McKinsey, 2010. McKinsey Global Survey Results: Assessing innovation metrics. Available at http://innovbfa.viabloga.com/files/McKinseyQuarterly__assessing_innovation_metrics__oct_2088.pdf
- McKinsey, 2013. Bullish on digital: McKinsey Global Survey results. Available at <http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/bullish-on-digital-mckinsey-global-survey-results>
- McKinsey, 2015. What 'digital' really means. Available at <http://www.mckinsey.com/industries/high-tech/our-insights/what-digital-really-means>
- Milbergs, Egils, and Nicholas Vonortas, 2004. Innovation Metrics: Measurement to Insight. White paper prepared for National Innovation Initiative 21st Century Innovation Working Group.
- Morris, Langdon, 2008. Innovation Metrics. The Innovation Process and How to Measure it. Innovation Labs. Available at http://innovbfa.viabloga.com/files/Innovation_Metrics_2008.pdf
- Nardo, M; Saisana, M; Saltelli, A; Tarantola, S. 2005. Tools for Composite Indicators Building. Italy: Joint Research Centre, European Commission.

- Nelson, R. (ed.) (1993), National Innovation Systems. A Comparative Analysis, Oxford University Press, New York/Oxford.
- NESTA, 2009. Measuring sectoral innovation capability in nine areas of the UK economy. Report for Innovation Index project.
- OECD, 1997. National Innovation System. Available at <http://www.oecd.org/science/inno/2101733.pdf>
- OECD, 2005. Oslo Manual (3rd edition). Available at <http://www.oecd.org/sti/inno/oslomanualguidelinesforcollectingandinterpretinginnovationdata3rdedition.htm>
- OECD, 2006. Community innovation statistics: from today's Community Innovation Surveys to better surveys tomorrow. Available at <http://www.oecd.org/science/inno/37489901.pdf>
- OECD, 2015. Frascati Manual 2015. Available at <http://www.oecd.org/publications/frascati-manual-2015-9789264239012-en.htm>
- Portfolio Innovation Index, 2016. <http://www.statsamerica.org/ii2/reports/Driving-Regional-Innovation.pdf>
- Rothwell, Roy, 1994. Towards the fifth-generation innovation process. International Marketing Review. 11(7), pp7-31.
- Saisana, M. 2004. Composite Indicators: A Review. Second Workshop on Composite Indicators of Country Performance. OECD, Paris.
- Sloat, Tyler (Year unknown). An introduction to subscription finance: strategies for understanding and growing your recurring revenue. ZUORA Academy. <https://www.zuora.com/guides/subscription-finance-basics/>
- The Conference Board, 2014. Designing Global Businesses for Innovation and Growth. Available at <https://www.conference-board.org/publications/publicationdetail.cfm?publicationid=2818¢erId=6>
- The Conference Board, 2016a. Navigating the New Digital Economy: Driving Digital Growth and Productivity from Installation to Deployment. Available at <https://www.conference-board.org/publications/publicationdetail.cfm?publicationid=7215¢erId=6>
- The Conference Board, 2016b. Digital Transformation: What Is It and What Does It Mean for Human Capital? Available at <https://www.conference-board.org/publications/publicationdetail.cfm?publicationid=7247¢erId=6>
- The Conference Board, 2016c. The Conference Board Sustainability Practices Dashboard (2016). Available at <https://www.conference-board.org/publications/publicationdetail.cfm?publicationid=7352¢erid=13>
- The Conference Board, 2017. The Conference Board CEO Challenge ® (2017). Available at <https://www.conference-board.org/publications/publicationdetail.cfm?publicationid=7399¢erId=9>
- Tidd, Joe, John Bessant, and Keith Pavitt, 2005. Managing Innovation: Integrating Technological, Market, and Organizational Change. Wiley. New York.
- Velu, C., M. Barrett, R. Kohli, T. Salge, 2010. Thriving in Open Innovation Ecosystems: Toward a Collaborative Market Orientation. Cambridge Judge Business School.

APPENDIX A:

Table 1: Engagements with Innovation Leaders on Developing the Signposts of Innovation Framework

	Description	Events & Activities
Councils	Councils of The Conference Board, composed of senior innovation executives from member companies, provide insights on signposts for assessing and predicting innovation	<p>Council meetings of various innovation councils:</p> <ul style="list-style-type: none"> -Innovation Council -Applied Innovation Council -Innovation Leadership Council -European Innovation Council -Products & Services Development Council
Seminars & Workshops	To obtain feedback from a wide range of innovation leaders and practitioners regarding the predictive signposts of innovation and how they might work at the company level	<ul style="list-style-type: none"> -Transforming Innovation Through Collective Disruption Seminar (1 Dec 2015) -4th Annual Innovation Master Class (8 Jun 2016) -The Future of Digital Transformation and Innovation unConference (6 Oct 2016)
Panels & Other Discussions	Panel and roundtable discussions with researchers and senior innovation executives to address the goals, challenges, and opportunities in innovation measurement	<ul style="list-style-type: none"> -Fireside Chat hosted by 3M, Saint Paul, MN (19 October 2015) -Cologne Institute for Economic Research Roundtable (29 Aug 2016) -Dallas Chamber of Commerce Innovation Panel (3 Oct 2016) -"One-on-one"" briefings with individual companies
Research Collaborations	Partnerships with academics and subject matter experts in the areas of innovation research and measurement with the aim to collect data and quantify innovation at the company level	<ul style="list-style-type: none"> -Innovation surveys of members of The Conference Board

APPENDIX B: Glossary

Innovation Framework

(the overall process of innovation/way that innovation is viewed by a company-- metrics are usually contextual)

An innovation framework fits together the different aspects of innovation within a company and facilitates understanding, management and evaluation of the resources, processes and potential outcomes of innovations. The framework provides concepts and relationships, and metrics or indicators are used to describe qualitatively or quantitatively those concepts and relationships.

Input Metrics

Input metrics are metrics describing and quantifying the resources used to develop innovations of a company.

Throughput Metrics

Through-put metrics are metrics are indicators that describe and quantify the intermediate results (not final results or the goals of innovation) from inputs. They describe the process between inputs and outputs and measure the processes that facilitate the development of the outputs..

Output Metrics

Output metrics are indicators describing the achievement of the goals of innovations. These indicators measure the progress or success of bringing innovations to commercial viability.

Soft Measures and Hard Measures

Soft Measures are qualitative indicators based on perceptions or sentiment about a product or service or a company. Hard Measures are quantitative or numerical indicators that track magnitudes of resources used in the process leading to innovations⁸.

Innovation Metrics

Indicators assessing the resources, efficiency, progress and performance of innovation.

Innovation Incentive

An inducement or supplemental reward that serves as a motivational device for a desired action or behavior that supports innovation within an organization.

⁸ Based on <http://www.carnegiimg.com.au/blog/soft-or-hard-measures/>

