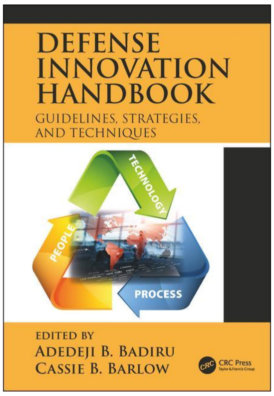

Defense Innovation Handbook
Guidelines, Strategies, and Techniques

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Definitional analysis of innovation

Publication details
https://test.routledgehandbooks.com/doi/10.1201/b22181-2
Adedeji B. Badiru
Published online on: 04 Sep 2018

chapter two

Definitional analysis of innovation[*]

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Contents

Introduction

A definitional analysis of innovation is essential for getting the intended full benefit of this chapter. Joe Sciabica, in the FOREWORD, reminded us of a dictionary definition of innovation:

> "Innovation a (noun) + a (verb) - The portfolio of financial, intellectual, organization and human capabilities that enable a society's journey to its desired future."

This definition of innovation conveys the multifaceted operational meaning of the word. This may help readers to put everything into the proper perspective. Innovation is widely heralded as essential for successful competition in the increasingly global economy. However, to enhance innovation in education, organizations and countries require transformative thinking. National thought leaders and organizations such as the National Academy of Engineering are supporting projects to explore this relationship. The Educate to Innovate (ETI) project was designed to explore the issue regarding teaching innovation and the expected outcome, entrepreneurship [1].

* This chapter is adapted and modified with copyright permission from Chapter 2 (The role of Creativity and Innovation in Leadership) of McCauley, Pamela (2017), **Essentials of Engineering Leadership and Innovation**, CRC Press/Taylor & Francis, Boca Raton, Florida.

During the 1950s and 1960s, Sputnik and the space race stimulated a generation of Americans to follow education and careers in science and technology. Half a century later, American students are now graded 22nd and 21st among their peers all over the world in science and math, respectively. Students in the United States, formerly a leader in science, technology, engineering, and mathematics (STEM), are now outperformed by students from Slovenia, Hungary, and Estonia, among others [2].

In 1983, the National Commission on Excellence in Education published "A Nation at Risk," a nationwide study that highlighted the intolerable state of the American education system:

> Our nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world. This report is concerned with only one of the many causes and dimensions of the problem, but it is the one that undergirds American prosperity, security, and civility. What was unimaginable a generation ago has begun to occur—others are matching and surpassing our educational attainments. If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. [3]

More than two decades afterward, in 2010, the National Academies of Science, Engineering, and Medicine published *Rising above the Gathering Storm, Revisited: Rapidly Approaching Category 5*, which built on the findings of its 2005 "Gathering Storm" report. Notably, the report warns that

> "Today, for the first time in history, America's younger generation is less well-educated than its parents" [4].

In an effort to respond to the faltering academic status of American students and in a quest to elevate them "from the middle to the top of the pack in science and math," the Obama Administration announced its ETI initiative in November 2009 [5].

President Barack Obama's ETI campaign is publicized as a joint effort between the federal government, the private sector, and the nonprofit and research communities to raise the standing of American students in science and math through dedication of time and money, and volunteering. The program attempts to enhance STEM literacy, improve teaching quality, and develop educational and career opportunities for America's youth.

At the time the program was first declared in November 2009, the participating organizations offered a financial and in-kind commitment of more than $260 million. Taxpayer commitments for the federal government's portion of ETI add to that total. In addition, five public-private partnerships were announced, as well as commitments by key societal and private sector leaders to muster funds for STEM education, innovation, and awareness [6]. These partnerships and commitments are:

- Time Warner Cable's Connect a Million Minds (CAMM), which pledges to connect children to after-school STEM programs and activities in their area.
- Discovery Communications' "Be the Future" will broadcast dedicated science programming to more than 99 million homes and offer interactive science education to approximately 60,000 schools.

- Sesame Street's "Early STEM: Literacy" commits to a two-year focus on STEM subjects.
- National Lab Day will promote hands-on learning with 100,000 teachers and 10 million students over the next four years and foster communities of collaboration between volunteers, students, and educators in STEM education. These initiatives will then culminate in a nationally recognized day centered on science activities.
- The National STEM Video Game Challenge promotes the design and creation of STEM-related video games.
- The annual White House Science Fair will bring the winners of science fairs from across the nation to the White House to showcase their STEM creations and innovation.
- Sally Ride, the first female astronaut, Craig Barrett, the former Intel chairman, Ursula Burns, CEO of XEROX, and Glenn Britt, CEO of Eastman Kodak, committed to fostering interest and support for STEM: education among American corporations and philanthropists [6].

In January 2010, President Obama announced the continuation of the program, stressing the half-billion-dollar monetary obligation from the administration's partners. This development includes an additional commitment of $250 million in financial and in-kind support, and a pledge by 75 of the nation's biggest public universities to train 10,000 new teachers by 2015. The program expansion also incorporated additional public-private partnerships anticipated to aid the training of new STEM educators, together with the launch of Intel's Science and Math Teachers Initiative and the PBS Innovative Educators Challenge, as well as the expansion of the National Math and Science Initiative's UTeach program and Woodrow Wilson Teaching Fellowships in math and science. In addition, the president called on 200,000 federal government staff working in the fields of Science and Engineering (S&E) to volunteer to work with educators in order to foster enhanced STEM education [6].

A STEM-educated workforce is very important for the protection and the wealth of the United States as industry and government increasingly demand exceedingly trained STEM professionals to vie in the international market and look to science and technology to help stay one step ahead of national security threats. The United States must not permit itself to be outcompeted in science, technology, engineering, and mathematics. While the Obama Administration's ETI enterprise is projected to raise the United States "from the middle to the top of the pack in science and math," this one-size-fits-all federal approach fails to cure the primary problems of educational performance and does not stop the permeable pipeline in the American education system.

The evolution of innovation

The principles associated with innovation can be applied to organizations, individuals, and product development. These three categories of innovation can also be applied simultaneously to create a culture where individuals are continually seeking to be innovative and create enhanced product outcomes. The meaning of innovation has evolved with US Federal funding agencies as well. For example, consider the National Science Foundation (NSF), one of the premier research funding agencies in the United States that funds 24 percent of all federally supported basic research conducted by colleges and universities in the United States each year [7].

For many years NSF largely focused on funding only basic research rather than funding applied research and technology transition. Now the NSF's funding goals are extending beyond basic research to support various aspects of groundbreaking applied research and the transition of research outcomes into useful products, services, and technologies. There's a good reason for this change in focus. Historically, it was thought that it could take up to 50 years for the knowledge learned from basic research to be applied to products and services. However, as the pace of change itself continues to increase, the speed of technology and new development has compressed the time it takes to move basic research from reaction to knowledge to actual application. The NSF reflects this shift quite powerfully in its desire to now fund more applied research. The quick transition of the NSF's innovation core and its desire to swiftly convert new knowledge into new products and services is solid evidence of change.

Discussion of 1-corp program and related National Science Foundation initiatives

America's affluence grew in part from the capability to profit economically on groundbreaking developments from science and engineering research. At the same time, a well-informed, imaginative labor force has maintained the country's international leadership in significant areas of technology. These essential discoveries and competent labor force resulted from substantial, incessant investment in science and engineering. A strong capability for leveraging essential science discoveries into influential engines of innovation is necessary to maintain our competitive edge in the future. The NSF supports fundamental research and education in science and engineering. NSF's dual role, distinctive among government agencies, results in new knowledge and paraphernalia as well as a competent ground-breaking workforce. These corresponding building blocks of innovation have led to innovatory high-tech advances and completely new industries. Through this program, NSF seeks to hasten the improvement of new technologies, products, and processes that arise from elementary study. NSF investments will advantageously strengthen the innovation ecosystem [8] by addressing the challenge built into the early stages of the innovation process. This solicitation will support partnerships that are designed to triumph over scores of obstacles in the path of innovation.

Program description

The objectives of this program are to encourage translation of fundamental research, to facilitate collaboration between the academic world and business, and to train students to comprehend innovation and entrepreneurship. The rationale of the NSF I-Corps program is to spot NSF-funded researchers who will obtain extra support—in the form of mentoring and funding—to hasten the conversion of knowledge derived from essential research into up-and-coming products and services that can attract successive third-party funding.

About the National Science Foundation

The NSF is an autonomous federal agency created by the National Science Foundation Act of 1950, as amended (42 USC 1861–1875). The act states the function of the NSF is "to promote the progress of science; [and] to advance the national health, prosperity, and welfare by supporting research and education in all fields of science and engineering" [7]. NSF funds research and learning in most fields of science and engineering through grants and cooperative agreements to more than 2000 colleges, universities, K-12 school systems, businesses, informal science organizations, and other research organizations all over the United States. The foundation accounts for about one-fourth of federal support to educational institutions for essential research. NSF receives in the region of 40,000 proposals each year for study, learning, and training projects, of which roughly 11,000 are funded. In addition, the foundation receives thousands of applications for graduate and post-doctoral fellowships. The agency operates no laboratories itself but does support national research centers, user facilities, certain oceanographic vessels, and Arctic and Antarctic research stations. The foundation furthermore supports joint research between universities and industry, US participation in global scientific and engineering efforts, and educational activities at every academic level [7].

The role of creativity and innovation has changed our nation because now we are pushing more to see these new developments converted into new products and services, and the driving factor in accomplishing this is leadership. There is even more accountability in terms of wanting to understand what has been done with research funding for over the past several years. Generally, Americans convey extremely favorable attitudes toward science and technology (S&T). In 2001, overpowering majorities of NSF survey respondents agreed with the following statements:

- "Science and technology are making our lives healthier, easier, and more comfortable" (86 percent agreed and 11 percent disagreed).
- "Most scientists want to work on things that will make life better for the average person" (89 percent agreed and 9 percent disagreed).
- With the application of science and technology, work will become more interesting" (72 percent agreed and 23 percent disagreed).
- "Because of science and technology, there will be more opportunities for the next generation" (85 percent agreed and 14 percent disagreed) [9].

In addition, Americans give the impression of having more positive attitudes toward S&T than their counterparts in the United Kingdom and Japan [10].

Despite these positive indicators, a sizable segment, although not a majority, of the public has some reservations concerning science, especially technology. For example, in 2001, approximately SO percent of NSF survey respondents agreed with the following statement: "We depend too much on science and not enough on faith" (46 percent disagreed). In addition, 38 percent agreed with the statement: "Science makes our way of life change too fast" (59 percent disagreed) [11].

Public attitudes toward federal funding of scientific research

All indicators point to general support for government funding of essential research. In 2001, 81 percent of NSF survey respondents agreed with the following statement: "Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the Federal Government" [12]. The level of agreement with this statement has consistently been in the 80 percent range. In 2000, 72 percent of U.K. residents agreed with the statement, as did 80 percent of Japanese residents (in 1995).

These differences in the measure of public support worldwide for basic research are notable. This may be attributed to the increased expectations in terms of transitioning science to technology and innovations. The result is people expect basic research to more readily provide benefits to society and in fact, in 2001, 16 percent disagreed with the statement completely. This suggests that they expected immediate benefits from basic research and this trend of expectation has continued.

Although there is strong evidence that the public supports the government's investment in basic research, few Americans are able to name the two agencies that provide most of the federal funds for this type of research. In a recent survey, only 5 percent identified the National Institutes of Health (NIH) as the agency that "funds most of the taxpayer-supported medical research performed in the United States," and only 3 percent named NSF as "the government agency that funds most of the basic research and educational programming in the sciences, mathematics and engineering" [13].

In addition, those with more positive attitudes toward S&T were more likely to express support for government funding of basic research. In 2001, 93 percent of those who scored 75 or higher on the Index of Scientific Promise agreed that the federal government should fund basic scientific research compared with only 68 percent of those with relatively low index scores [13].

In 2001, only 14 percent of NSF survey respondents thought the government was spending too much on scientific research; 36 percent thought the government was not spending enough, a percentage that has grown steadily since 1990, when 30 percent chose that answer [14]. Men are more than likely than women to say the government is spending too little in support of scientific research (40 percent versus 33 percent in 2001).

To put the response to this item in perspective, at least 65 percent of those surveyed thought the government was not spending enough on other programs, including programs to improve health care, help senior citizens, improve education, and reduce pollution. Only the issues of space exploration and national defense received less support for increased spending than scientific research.

In 2001, 48 percent of those surveyed thought spending on space exploration was excessive, the highest percentage for any item in the survey—and nearly double the number of those who felt that the government was spending too much on national defense [15]. In contrast, the latter fell steadily, from 40 percent in 1990 to 25 percent in 2001.

Definitions of innovation

Definitions of innovation differ but the general thread among these definitions is that innovations present a new or better product, service, or resource that adds "value" to those seeking it. The ETI study conducted 60 interviews that revealed common characteristics of innovators. A prevailing aspect of innovation is team interaction or team activities. For these teams to be effective, they are often managed by a technical person with detailed knowledge of the proposed innovation. In these situations, it is imperative that the team leader understands how to inspire, motivate, and lead the team as they move toward a useful innovation. When innovators were asked to describe characteristics of innovations or innovative products, the following characteristics emerged:

- *Innovation provides societal value*: The interviewees felt powerfully that innovations must offer societal value. The innovation must be supportive to society. It's great if one makes an invention, but it's even better if the invention can be used to develop individual lives. Part of the importance of an innovation is connected to timely adoption. It should be helpful in the near future. In truth, unless an innovation is in fact used by society, it cannot be called an innovation: R. Graham Cooks [16] warned innovators against believing that all they do is collectively meaningful or useful. In other words, if you feel that you have some fondness for innovation, then the big danger is that you'll convince yourself even in cases where the work is trivial or doesn't have the implications that you hoped it would have. Robert Dennard [16] agreed: "Lots of inventions aren't innovations. I have 62 patents and only one or two are actually being used, and if it's not used, it's really not innovating very much. So, innovation's a breakthrough, something that's really useful and it doesn't have to be patentable, even."

- *Innovation is an Improvement*: Innovations are naturally seen as "something new." Nevertheless, all the interviewees and workshop participants accentuated that innovations are improvements, not necessarily just new. Laurie Dean Baird [16] gives details of her approach to telling the difference in the value of an innovation. "If I look at something that is new and ask 'Is this innovative?' then I ask how was this problem solved before? What was the industry standard and how is this different?' And if the answer is that, in addition to being new (the problem or solution), it takes the hassle out of something (i.e., it improves life), then it is innovative."

> "I don't see innovation being the introduction of something [that is just] new," Tim Cook says. "There are many things new every day, and I wouldn't say they all are innovative. I think to be innovative, something has to be better than the predecessor product, materially better, not just a small percentage better" [16].

In terms of the level of improvement, innovations can be transformational, for instance, creating large-scale changes in the way technology is used or thought about. Mary Lou Jepsen [16] said, "I think of innovation as doing some transformative work in an area or in a combination of areas that trail blazes in a way that people recognize has moved the ball forward... in a way that is a leap."

But it is not compulsory that every innovation be pioneering or radically change the world. Bernard Meyerson [16] referred to "continuous innovators." "The danger is there are other types of innovators that are just as necessary, what I call the continuous innovators. These are the guys who come to work every day and make it 5 to 10 percent better, and there's a terrible undervaluation of that."

- *Innovation occurs at the interfaces of different disciplines*: Innovators in all the areas represented, that is, academia, large companies, small businesses, and the arts, acknowledged that innovation occurs at the edge of disciplines and necessitates the synthesis of knowledge from dissimilar fields. Yo-Yo Ma [16] captured this aspect using the concept of the edge effect from ecology: "If you think about where new ideas can come from, you need proximity to density, and if you're at the edge of something you see both sides; you already see over the wall. You could be part of one ecosystem, but you actually are constantly interacting with another ecosystem, and so you see the possibility of what another ecosystem can bring. And... if the center uses the knowledge at the edge, the center does benefit."
- *Teamwork is important to the process of innovation*: Innovation is the effect of joint effort, a point frequently made by the innovators. And it relies on the work of the team as a whole, not the work of one key innovator and other Supporters." Ivan Seidenbergt [16] observed: "I get comfort in knowing that life is cumulative, innovation is cumulative, and it's not individual. Let's take some of the greatest examples: Let's start with the example everybody's using right now, and I knew him well. Steve Jobs was a genius, but he didn't invent the computer. He didn't invent anything that went into the iPhone, but he made it all work together... so what did he invent? Take another

example: Bill Gates had enough common sense and enough vision to know that PCs couldn't talk to each other, so he built operating systems to make them talk to each other, but along the way, they didn't work very well when they first came out with them. They (Jobs and Gates) needed a full team and with their superior insights and innovative spirit, they made something bigger than any one person could have made. So, all I'm getting at is that there's really no one innovator who can innovate all alone. I can't think of any one person that gets it all right. Is there anybody? Is there anybody in the literature that gets it right the whole time?"
- *Innovation is part of an invention-value continuum*: Innovation is part of a field between invention and worth. Innovators may start with a discovery and then innovate to generate value from it, or start with a problem and solve it innovatively. Innovation was portrayed as the use of inventions to real-world needs. Innovation can also be driven by the impression of marketability or attempt to solve a problem. As Robert Fischelr [16] said, "Sometimes we see an invention and then we can apply it to another thing, but that doesn't happen very often. Most times, we hear about something and it occurs to us that the way they're doing it is not good, and so we innovate a better way."

Analysis of the 60 innovators' observations disclosed that innovation is an enhanced product, process, or service that profits society in a timely and, sometimes, transformational manner. It is a team activity at the meeting point of diverse fields, bringing as one diverse ideas, skills, and/or methods to result in the production of value.

Types of innovation

Innovation applications are commonly applied to a product, a process, or a service. To additionally comprehend how this is done, let's reflect on three categories of innovation:

Product innovation

Product innovation is about making valuable changes to material products. Interrelated terms that are frequently used interchangeably comprise product design, research and development, and new product development (NPD). All of these terms proffer a particular viewpoint on the degree of alteration to products. Well-known organizations characteristically have a collection of products that must be incrementally enhanced or adjusted as problems are recognized in service or as new requirements emerge. It is imperative that they also work on add-ons to the product families. One of the major actions of the product design team is the work it carries out on next-generation products or new models of products. They might also work on designing far-reaching new products or new core products that enlarge the portfolio considerably and frequently involve drastically new processes to produce them. These new core products idyllically present the organization with the possibility of major increases in revenue and growth, which can also create the potential of short-term monopoly in the market.

The product development process for next-generation and new core products, according to Cooper, follows a familiar cycle in most organizations:

1. Ideation
2. Preliminary investigation
3. Detailed investigation

4. Development
5. Testing and validation
6. Market launch and full production [17]

All of these steps involve communication with customers, who might take part in idea creation and element recognition. Key performance criteria in the design process revolve around the following:

1. Time to market
2. Product cost
3. Customer benefit delivery
4. Development costs [18]

These standards can be traded off against one another. For instance, development costs can be traded against time to market, customer benefits can be traded against product costs, and so on. Three blueprint systems have become known as providing a management system for efficient product innovation: phase review, stage gate, and product and cycle-time excellence (PACE).

1. *Phase review*: This technique splits the product development life cycle into a sequence of different phases. Every phase encompasses a body of work that, once finished and evaluated, is dispensed over to the next phase. No consideration is paid to what may or may not occur in the succeeding phases, principally for the lack of knowledge or exclusive focus on the job in the existing phase. The phase review technique is a chronological rather than a simultaneous product design method, that is, each phase is accomplished and concluded before the commencement of the next phase.
2. *Stage gate*: This technique is a simultaneous product design procedure that follows a prearranged life cycle from idea creation to market commencement [17]. The stages in this technique are first and foremost cross-functional. Stage gates appear at the end of each stage, where a design evaluation takes place. Each stage gate evaluates the decided deliverables for completion at the conclusion of the stage, a checklist of the standard agreed for each stage, and a choice about how to advance from a particular stage.
3. *PACE*: This method is concerned mainly with enhancing product improvement strategies [18]. The technique connects product strategy with the general strategy and goal of the organization. A key element is positioning of the voice of the customer all through the product design procedure. Strategies are divided into six product strategic thrusts: expansion, innovation, strategic balance, platform strategy, product line strategy, and competitive strategy. Product innovation methods and processes are one element in an organization's mission to create value for customers.

Process innovation

Process innovation can be observed as the launching of a new or considerably enhanced method for the construction or delivery of production that append value to the organization. The term *process* refers to an interconnected set of actions designed to convert inputs into a specific result for the customer. It implies a strong prominence on how work is done within an organization rather than what an organization does [19].

Processes recount every operational action by which value is presented to the end client, such as the purchase of raw materials, production, logistics, and after-sales service. The process innovation in the 1970s and 1980s gave Japanese manufacturing a viable advantage that permitted them to take over some international markets with cars and electronic goods. Likewise, process innovation has permitted organizations such as Dell and Zara to achieve competitive advantage by offering higher-quality products, delivered faster and more proficiently to the market than by the competitors. By focusing on the resources by which they transform inputs, such as raw materials, into results, such as products, organizations have achieved efficiencies and have added importance to their production. Process innovation permits some organizations to contend by having a further proficient value chain than their rivals have.

Process innovation has resulted in organizational enhancement such as lower stock levels; quicker, additional flexible production processes; and more responsive logistics. Organizations can develop the competence and value of their processes with a huge array of diverse enablers. Even though the use of these enablers is dependent on the organizational framework, many present the possibilities for improved process performance. The application of technology such as robotics, enterprise resource planning systems, and sensor technologies can change the process by decreasing the price or variation of its output, improving safety, or decreasing the throughput time of the process.

Service innovation

Service innovation is concerned with making changes to intangible products. Services are frequently linked with work, play, and recreation. Examples of these types of service consist of education, banking, government, recreation, entertainment, hospitals, and retail stores. In the past decade, an enormous amount of knowledge-based services has been accessible through websites. These services involve intangible products, have a high quantity of customer dealings, and are typically set in motion on demand by the customer. Defining a service can be to some extent problematic. Some define service as a sequence of overlapping value-creating activities.

Others define service in terms of performance, where customer and provider coproduce value. There are three categories of service operations:

1. Quasi-manufacturing (e.g., warehouses, testing labs, recycling)
2. Mixed services (e.g., banks, insurance, realtors)
3. Pure services (e.g., hospitals, schools, retail)

Services can without a doubt involve products that form a comprehensive part of the product life cycle, from preliminary sales to end-of-life recycling and clearance. Service business in areas such as finance, food, education, transportation, health, and government make up most organizations in any economy.

These organizations as well require innovation incessantly so that they can enhance levels of service to their customers. A key characteristic of a service is a very high level of communication with the end user or customer. The customer is often not capable of separating the service from the person delivering the service and so will make quality postulation based on impressions of the service, the group delivering the service, and any product delivered as part of the service. An additional feature of some service organizations is that their product may be perishable; consequently, the product must be consumed as soon as possible following purchase. Consequently, the timing of the delivery and customer opinion of quality are vital to success.

The notion of service quality is of particular significance. Service quality is a function of numerous factors including the uniqueness of offerings, intangibilities such as customized customer contact or perishable manufacture, and a continued capacity for innovations of the service. Another important driver of service innovation comes from the possibilities afforded by the new information technology podium, predominantly the Internet. The Internet is a priceless resource on which new service associations between organizations and their customers are being developed every day.

Innovation and entrepreneurship

If innovation is successful, the expected outcome is the transitioning of these new products, processes, or services into useful products that people are willing to pay for in the United States and globally. Although innovation and entrepreneurship are related, many caution against focusing too much on entrepreneurship in the initial stages of the creative aspect of innovation. This perspective believes that entrepreneurship should be a natural outcome of entrepreneurship but should not be the initial focus.

It is really important to lead with "innovation" and have it evolve into "entrepreneurship" because innovation is the large end of the funnel that appeals to and actually requires participation by a much broader audience. Non-business, non-engineering, and non-STEM people are every bit as important to include in that innovation process because the process is not as rich and has inferior outcomes without that diversity [20]. In order to see this type of innovation systematically realized, engineering leaders must understand principles that should be integrated into the creative process to produce effective innovations.

The terms *entrepreneurship* and *innovation* are over and over again used interchangeably; nevertheless, this is deceptive. Innovation is frequently the starting point from which an entrepreneurial business is built for the reason of the competitive advantage it offers. On the contrary, the act of entrepreneurship is simply one means of bringing an innovation result to the marketplace. Technology entrepreneurs regularly decide to build a startup company for a technological innovation. This will offer financial and skill-based resources that will take advantage of the chance to grow and commercialize the innovation. Once the entrepreneur has set up a business, the focal point shifts in the direction of its sustainability, and the best way to attain this is through managerial innovation. Nonetheless, innovation can be conveyed to the market by ways other than entrepreneurial startups; it can also be subjugated through well-known organizations and deliberate alliances between organizations.

Case study: Charles Dow

In 1896, Charles Dow created the Dow Jones Industrial Average in order to provide a snapshot of the US economy through the stock market There were 12 companies on Dow's original list: American Cotton Oil, American Sugar, American Tobacco, Chicago Gas, Distilling & Cattle Feeding, General Electric (GE), Laclede Gas, National Lead, North American, Tennessee Coal and Iron, US Leather pfd., and US Rubber. Of all of those companies, which were financial leaders at the turn of the 20th century, there is only one you might recognize that is still in business today: General Electric.

What is the key to GE's century-long tenure? Product innovation. According to business researchers Heath Downie and Adela J. McMurray, "The consistency of GE's commitment to product innovation was made possible by the steadiness of the company's leadership." Even during the Great Depression, GE found a way to allocate diminishing financial resources to its research and development initiatives.

Today, GE has taken their commitment to innovation even further, crowdsourcing both internally and externally to drive advancements in several industries. In fact, GE has an Open Innovation Manifesto, in which they state:

We believe openness leads to inventiveness and usefulness. We also believe it's impossible for any organization to have all the best ideas, and we strive to collaborate with experts and entrepreneurs everywhere who share our passion to solve some of the world's most pressing issues [...] We'll never stop experimenting, collaborating and learning-we'll get smarter as we go, and the Global Brain will evolve and grow with us.

GE has a hand in advancing just about every engineering industry you can think of such as aviation, software, consumer goods, water and wastewater, power and energy, transportation, and healthcare, to name a few. Named "America's Most Admired Company" in a poll conducted by Fortune magazine and one of "The World's Most Respected Companies" in polls by Barron's and the Financial Times, the quality work GE has done for the planet has not gone unnoticed, and their leadership is extremely dedicated to quality and innovation. Take, for instance, Deb Frodl, global executive director of GE Ecomagination. Ecomagination is a business initiative designed by GE to develop innovative solutions to environmental challenges while driving economic growth. In an interview with Cleantech Group, Frodl said:

> Innovation is the foundation for Ecomagination and we have really developed a lot of solutions that solve complex problems for a multitude of industries. [...] Ecomagination has really been the catalyst within GE to step outside and get those ideas and that outside innovation moving forward.

In 2016, GE announced it would be relocating its corporate headquarters to Boston, Massachusetts, in part to enable GE to place additional emphasis on digital industrial innovation. This is further proof of the company's commitment to innovation and its leaders' push to improve access to a more innovative workforce and relocate to a better environment for innovation.

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