Sustainable innovation and knowledge management in the digital age and in the COVID-19 pandemic crisis

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Abstract: *In today's turbulent business environment sustainable innovation is imperative for the survival of the organisation and its success in the dynamic market of the digital age. This is especially true in the current COVID-19 pandemic crisis. A distinguishing feature of the modern digital age is that changes are occurring at unprecedented rates of velocity and scale, which leads to the necessity of a more flexible approach to strategizing and problem solving. The application of sophisticated technologies with the ability to disrupt the existing processes of value creation, is often regarded as a main feature of innovation. However, one of the most important lessons from the current global outbreak of coronavirus is that innovation can also be the product of urgency.*

The aim of this paper is to present the key role of knowledge management and complex open innovations, powered by the fusion effect of various team efforts, technologies, ideas and strategies, as a sustainable core competence of the organisations. The emphasis falls on open and convergence innovations, including their autonomous ecosystem, enabled by advanced technologies, unique life cycle features and relationships with other innovation approaches. Attention is brought to the creation of value for the stakeholders and for society as a whole. Innovation, especially in the time of crisis, requires not only collective intelligence to repurpose for shared organisational goals, but also collaborative efforts to merge different ideas with actionable plans.

The paper also outlines the differences and relationships among the various sustainable innovation strategies, ranging from finding new solutions to existing problems to redefining existing needs and finding new solutions. Examples are given of successful innovations developed during the pandemic. Furthermore, suggestions are made how knowledge management and innovations can be a catalyst for managing the current COVID-19 pandemic and charting potential paths for minimisation of the effects of the crisis.

Key words: *innovation, sustainability, knowledge management*
JEL codes: *O32; O31; L2; M14*

Introduction

The business environment has always been turbulent and in constant change, but what distinguishes today's digital age is that changes are occurring at unprecedented rates of velocity and scale (Brosseau et al., 2019). Today many organizations, especially small and medium enterprises (SMEs), don't have the luxury of developing strategies for intervals of several years, but are struggling to find survival plans for the next quarter or months (Blackburn et al., 2020). The wave of mega-trends, such as globalization, advances in technologies, environmental concerns, changing demographics, urbanization, the global pandemic crisis, and other forces, makes the marketplace increasingly uncertain. The environment is becoming even more complex as those mega-trends themselves are also evolving constantly. Also, advances in digital technologies occur at the speed of light, such as cloud-based computing, big data analytics, artificial intelligence (AI), machine learning, Internet of Things (IoT), autonomous systems, smart robots, 3-D printing, and virtual and augmented reality (VR & AR). These technologies are not only changing the way organizations function and people live, but they have also proven to be extremely valuable in addressing social problems. For example, in developed countries advanced digital technologies are extensively applied to testing, contact tracing, and treating people for the coronavirus; to quickly restructuring supply chains; to supporting tele-work and remote education which has the potential to permanently change the nature of work and education in the future; and for searching for robust solutions to derailed economic and social structures (Sneader & Singhal, 2020). Another aspect of the current unprecedented pandemic crisis is that it provides prompting to many organizations to be in a state of urgency for innovation like re-purposing businesses, products, materials, etc. to quickly deploy innovative solutions (Bello et al., 2020; Stoll, 2020).

The Evolution of Innovation

Innovation has been defined in many different ways, based on purpose, process, or disciplinary perspectives. In this paper, innovation is defined as "deployment of new ideas and/or technologies in fundamentally different ways to create new or additional value for continued success of the organization and its stakeholders" (Adner & Kapoor, 2010). In the current digital age, innovation is not equivalent to technology-enabled automation for achieving economies of scale. Today, innovation can be based on convergence of seemingly

heterogeneous and unrelated things that can create an exponential outcome based on the economies of convergence and network (Sjodin, & Parida, 2019).

It should also be pointed out that in recent years the pace of innovation has been frantic due to the rapid advances in technologies, sciences, the digital transformation of organizations; the compounding effect of the increasing complexity of the extended global value chains; and the recent COVID-19 pandemic crisis (Bello et al., 2020; Ip, 2020; Stoll, 2020; Tonby & Woetzel, 2020). Other factors underlining the greater need for novelty solutions are on one hand, the aging population in the Western world, and on the other, the rising income of the middle class in densely populated countries such as India. Also, the rising concerns with ethical and ecological norms require companies to look for expertise outside their own core businesses and to collaborate with various partners to ensure their products and services are up to the rising requirements of consumers in those areas. Thus, innovation has become an imperative for organizational sustainability and has demonstrated its significance times and times again.

Innovation based on the exponential effect of convergence, which is labelled as convergence innovation (CI) in this paper, is much more dynamic than automation, because it leverages the force of fusion of various objects, ideas, people, functions, technologies, organizations, industries and societies. The key feature of CI is the ecosystem, which is designed to make necessary decisions or actions autonomously, through scanning the environment with the support of smart sensors, AI, IoT, big data analytics and machine learning. The extracted relevant information is then sent to the next level for evaluating innovation ideas derived from both internal and external sources for implementation (Lee & Lim, 2018). The fusion of technologically advanced solutions with sound, strategic knowledge management practices inside the company can enable seamless and repeatable results. In this aspect, KM and CI could turn into a sustainable core competence for not only creating value, but also pursuing a smart future where people, society, and the environment all flourish (Hedvall et al., 2019; Lee & Lim, 2018; Lee & Trimi, 2018).

Looking at the process as a whole, the key phases of innovation evolution can be defined in the following manner:

1. Closed innovation (internal R&D focused, strictly protected as the source of competitive advantage)
2. Collaborative innovation (collaboration with partner organizations to create global value chains in the form of strategic alliances, joint ventures, technology licensing agreements and market partnerships)

3. Open innovation (searching for new sources of innovation ideas by leveraging collective intelligence and open sources)
4. Co-innovation (partnership of organizations, which share same basic goals, engage in co-creation of value, while each brings its specific core capabilities to the value chain)
5. Convergence innovation (bundling or fusing of seemingly unrelated objects, ideas, or experiences from all kinds of external sources including organizations and people from different industries and countries that share aspirational goals of stakeholders (Freeman, 2004) and for the greater good (Lee & Lim, 2018). Digital transformation, and by proxy convergence innovation, is enabled not only by advanced technologies, but also by the process of co-creation of shared goals (Porter & Kramer, 2011).

Structure of Convergence Innovations

In the hypercompetitive global business environment the sustainability of an organization depends on its agility, adaptability and resilience (Von Briel et al., 2019). Thus the primary purpose of CI is to support such organizational competitiveness. The ecosystem structure of the CI is composed of the following layers, which all interact with one another:

- Layer 1 is the direct contact point with the market forces, including customers, competitors, market conditions (e.g., economic, cultural, political and environmental conditions), and technological developments. This layer is composed of a web of AI-enabled smart sensors that can track the conditions and movements in the marketplace. The collected data are transmitted in real-time for big data analytics. The relevant information extracted by the data analytics system is forwarded to the autonomous decision-making system, which is su ported by machine learning, IoT, and other digital technologies, invokes instantaneous implementation of required actions. The higher-order collaboration or decision-making issues are forwarded to Layer 2 and above.
- Layer 2 has a host of connected innovation subsystems such as internal R&D, connect and develop (C&D) for external sources, collaboration networks with partner organizations and other stakeholders (e.g., customers, communities and governments), and open source systems (e. g., open innovation, crowd sourcing and public sources). These sub-systems are connected to the organization's tacit filter system, which processes and evaluates ideas from the various sources, including those that are

transmitted from Layer 1 based on the organization's capabilities and strategies. From this level on, a viable knowledge management system becomes paramount.

- Layer 3 consists of a value co-creation platform, where the organization attempts to co-create shared goals with major stakeholders, including customers, suppliers, other partner organizations, community, governments and society at large (Ramaswammy & Ozcan, 2014). The major decision problem at the platform involves priorities assigned to different goals associated with each stakeholder entity. Thus, strategic decisions based on the organization's vision and long-term goals at the top management level would be required.
- Layer 4 is the highest level of the ecosystem from which the purpose of innovation transcends down to lower layers for implementation. While value creation is the immediate goal of most organizations, as well as the interest of all stakeholders (Freeman, 2004), the ultimate goal of innovation can be much more far reaching and aspirational than that. The goal of innovation could be for the greater good (beyond that for the organization and its stakeholders) - creating a smart future where people, organizations and the environment all flourish (Hunt, 2017).

The proposed model of CI is in line with the current active research on autonomous organizations as proposed by Libert, Beck, and Davenport (2019). While self-driving enterprises are not reality yet, many functional areas have seen innovations toward semi-autonomous operations. Libert et al. (2019) suggest the following scale to measure a system's autonomy:

1. Human controlled, with autonomous systems providing supporting data/information
2. Human controlled, with most systems operating autonomously with preset guidelines and warnings
3. System controlled, with frequent human intervention and support for decision-making
4. System controlled, with human intervention for critical decision problems
5. Completely system controlled, with no human intervention or support

The proposed model of CI can be defined as being around level 3 on this scale.

Innovation Knowledge Life Cycle

Since innovation is a knowledge-intensive process, in which existing knowledge is applied and new knowledge constantly created, the innovation process is strongly connected with knowledge management and the two intertwine at most levels of the process. It is the general baseline of most approaches to knowledge management that knowledge is more useful if it does not reside in the minds of individuals, but is applied and made available to others and that this flow is crucial for the creation of new knowledge.

The Innovation Knowledge Lifecycle (IKLC), describing the use and creation of knowledge in the innovation process includes the knowledge cycle and the problem cycle (see Figure 1). The knowledge cycle is based on existing knowledge life cycles and covers the flow of knowledge in the innovation process with a special focus on knowledge application. Especially, it follows the argument of Fischer & Ostwald, 2001 that knowledge creation is integrated into the work process and is not a separate activity and this attitude corresponds well with the core concepts of CI. Thus the IKLC can be a supporting factor when developing convergence innovations in each layer after the first.

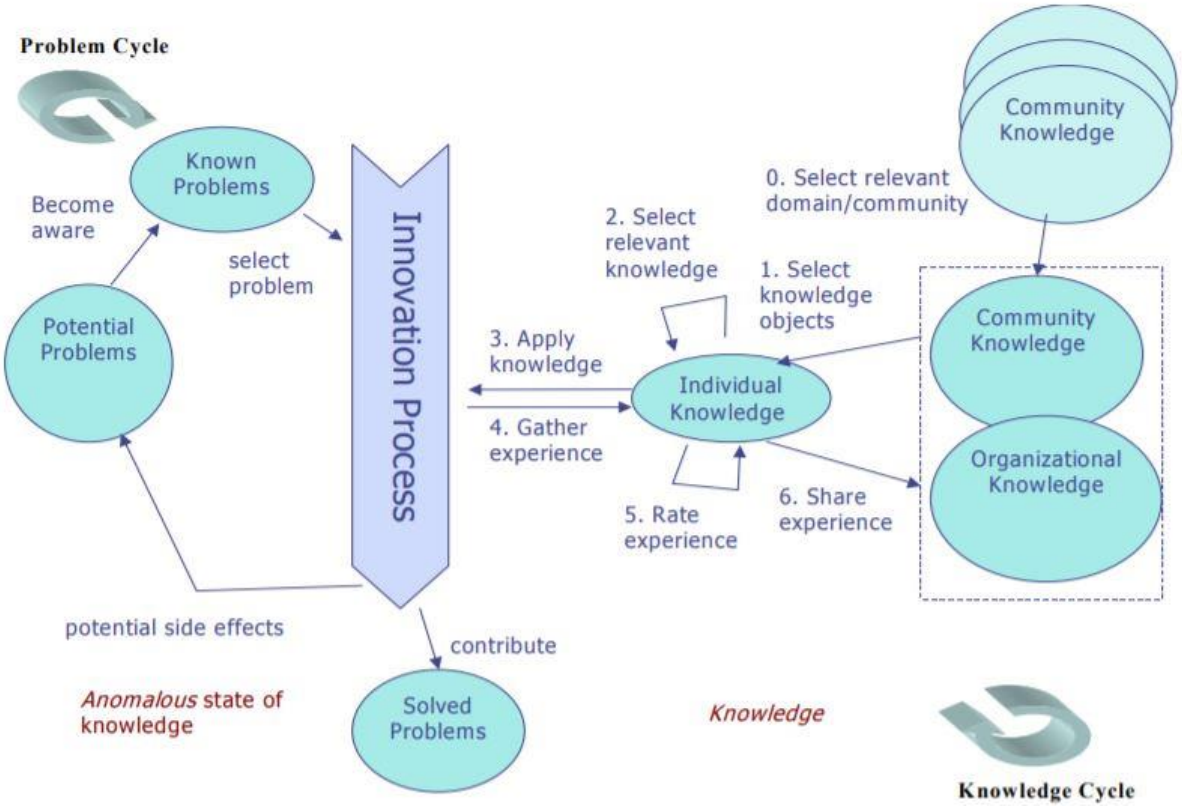

Figure 1: Innovation knowledge life cycle (Paukert et al., 2004)

The knowledge cycle distinguishes three basic types of knowledge: community knowledge and organizational knowledge, shared by a community or within an organization, respectively, and working knowledge, the knowledge at hand in a concrete working or task context. In case of an individual activity this is the personal knowledge of an individual, whereas in case of a team effort, the working knowledge is the relevant joint knowledge of all the team members. The knowledge cycle contains 7 main steps:

- *Select relevant domain/community:* An innovation process is embedded into an application domain with an associated community, whose knowledge is applied when solving problems during innovation. However, facing the current problems of a new kind requires radically new solutions, so it is necessary to explore the knowledge of different communities and domains. The identification of one or more relevant knowledge domains is an iterative process and remains a core building block for developing CIs.
- *Select Knowledge resources:* After identifying relevant communities, adequate knowledge resources need to be selected. Working knowledge refers to individual or team knowledge and identifying such knowledge objects also includes the internalisation of knowledge (Nonaka & Takeuchi, 1995). These first two steps are only necessary if the existing working knowledge is not sufficient to perform the current activity or solve the current problem. Typically larger steps in innovation will require effort into these two phases.
- *Focus on relevant knowledge*: At each point of the innovation process only a small part of the working knowledge is relevant. Focusing on the relevant knowledge is also an iterative process of selecting and rejecting knowledge objects. This can be an individual mental process or may require negotiation in a cooperative context, the second becoming more prevalent in the current global conditions.
- *Apply knowledge:* The selected knowledge is applied in performing a step in the innovation process, e.g. solving a problem or developing an idea. Before the knowledge can be applied it has to be adapted to the current context of use. The required effort depends on how different the current situation is from the situation the knowledge was gained from.
- *Gather Experience:* Experience is gathered from observations and insights during the performance of the activity and from the application of the knowledge in this

situation. This refers to the question, if the chosen knowledge has been adequate to solve the current problem.

- *Rate Experience:* In this step the gathered experience is put into relationship with the goals of the innovation process and is rated from this point of view. This rating provides the basis for the decision about further actions. For cooperative activities the rating may require a negotiation between the team members.
- *Share Experience:* Gathering and rating of experiences produces new knowledge. In the ideal case, the rated experience and the resulting knowledge are made explicit as knowledge objects, so they can be shared with other people and by this way closing the knowledge cycle. But this requires extra effort, which has to be well motivated (Fischer & Ostwald, 2001). Even negative experience represents knowledge that might become valuable at a later point in time and effort should be made towards making it explicit.

The main purpose of the knowledge cycle is to provide a sound starting point for considering the specific knowledge handling requirements in the different phases of the innovation process. That's why the steps of the knowledge cycle are described on an abstract level, which makes them flexible enough to be applicable throughout the whole CI development and deployment cycle.

Life Cycle of CI

Innovation is rarely a one-shot process. Instead, it usually involves a life cycle (Ettlie, 2006). The first mover advantage, based on new technologies and/or new business models, may last several months, years, or even longer, until new entrants with new innovative products/services disrupt the market. But in the competitive digital age, the innovation life cycle has become much shorter as in many cases organizational core competences are based on fast developing technologies (Lee & Trimi, 2018).

Typically, the innovation life cycle resembles the S-curve of technology (Ettlie, 2006). At the start of the curve, a new idea is planted for different ways of creating value and necessary resources are committed for its realisation. Many innovative ideas, inventions, patents or business models may not pass this phase, if they don't prove themselves viable enough. Some may receive management support and the required resources for implementation, but die down without reaching the take-off stage. Other innovations may have a long life cycle with steady marginal rates of return (e.g.,

consumer products, paper products, and food items). However, a successful innovation would have an S-curve as shown in Figure 2: after launching the innovation, the marginal rate of return increases exponentially until it reaches the inflection point - this is typically the 'harvesting' phase of innovation where the marginal rate of return begins to diminish until it reaches the peak of the curve. In order to minimize loss, the firm may abandon the innovation before its return begins to turn into a negative and it may start a new cycle instead.

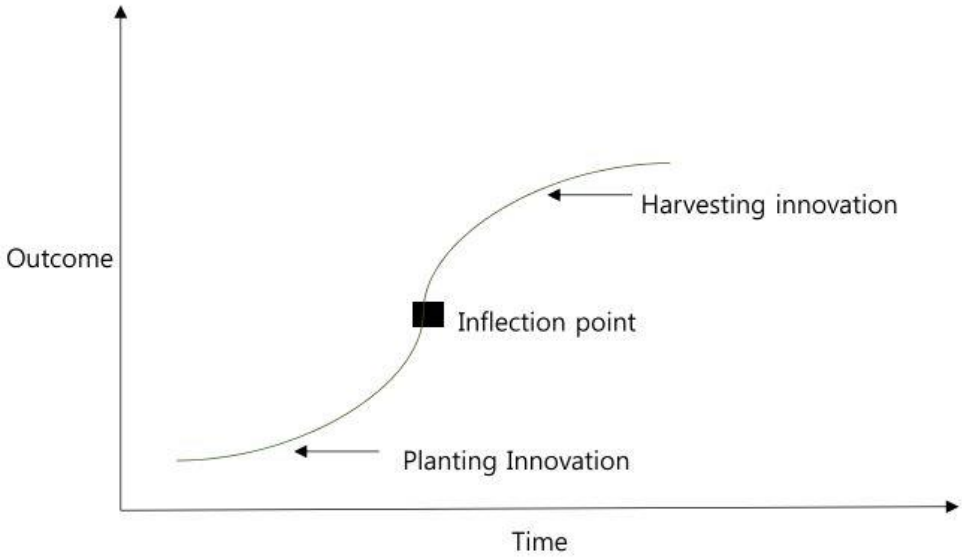

Figure 2: Innovation life cycle S-curve (Ettlie, 2006)

But in today's climate, a well-adjusted firm should have a proactive strategy for continuous innovation. When the first innovation S-curve reaches its peak point, it should be able to launch the next S-curve by leveraging both the learning experience from previous innovations and the new technological advances (see Figure 3). In the life cycle figure, X-axis represents time, while Y-axis shows the outcome of innovation in terms of value added (e.g., value chain efficiency, new products/services, new customer value, new markets, or new business models).

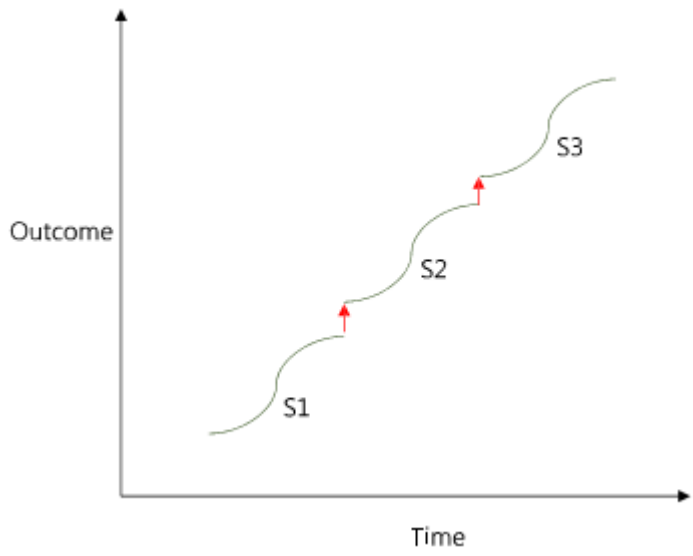

Figure 3: Continuous innovation S-curves (Lee, Trimi, 2021)

CI S-curves in the digital age would be different than the continuous innovation S-curves shown in Figure 2 and Figure 3, which are based on the economies of scale or network. CI will typically have shorter S-curves and the successive S-curve would start from a higher point than the peak of the previous curve, due to exponential effect of convergence. Also, the length and trajectory of S-curves would vary depending on the nature of the innovation. In addition, the transition line from the peak of the previous S-curve to the starting point of the next S-curve would be jagged and jumpy, just like the general pattern of technology development (Lee & Olson, 2010). The new starting points of successive S-curves would depend on the nature of convergence and technologies involved, see Figure 4.

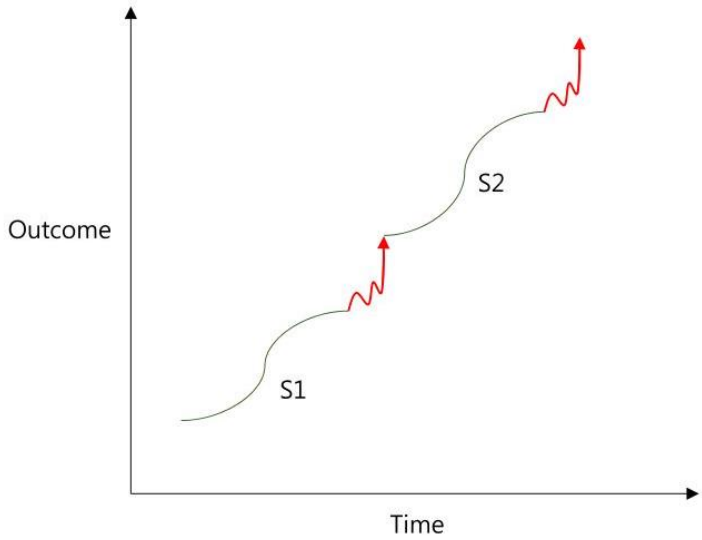

Figure 4: Convergence innovation S-curve (Lee, Trimi, 2021)

Significance of CI in the Covid-19 Pandemic

In the face of the ongoing pandemic, the most urgent steps to take are deploying effective measures in place. Such quick, decisive activities are the core elements of CI, which indicates that CI is not only applicable for ordinary times, but it is even more effective in times of crisis. To manage the pandemic crisis, the following activities could be deployed:

- *Real-time environment scanning*: In order to understand the severity and magnitude of the virus, each society needs a smart, robust infrastructure. It is impossible to fight a virus of such magnitude without a main centre which can collect and analyse data. South Korea has been singled out as the most successful nation in managing the pandemic thanks to its public health infrastructure, the outcome of the country's lessons learned from battling MERS in 2012 (Reuters, 2020). The critical chain for effective management of the pandemic involves: testing, tracing contacts of infected persons, quarantine or treatment, securing the care capacity (medical staff, hospital facilities, personal protective equipment (PPE), and after treatment logistics). With its world-leading mobile communication systems, in South Korea contact tracing was done instantaneously, which is one of the key factors for the containment of the virus.
- *Seamless flow of data, analytics, and information for decision making*: The key to innovation success is that the valuable information extracted from data analysis is quickly applied to decision making. The rapid spread of the virus paralyzed most economies, especially in sectors such as air transportation, hospitality and tourism, entertainment, sports and education. While economic stimuli are being applied worldwide in order to counter the economic impact of the pandemic, it's still unclear if such measures will achieve the desired results.
- *Collaboration network*: COVID-19 is a global pandemic and as such it cannot be controlled, nor can its treatment and vaccine be effectively implemented by just one country in isolation. International collaboration among public health organizations, governments, and medical professionals is essential. A good example is the fact that the Federal Drug Administration (FDA) approved Gilead Science's intravenous drug Remdesivir on May 1, 2020 in lightning

speed of several days, after the drug showed 31% improvement in recovery among 1063 severely ill patients (Associated Press, 2020). Many other partnerships have been formed quickly among scientists, private foundations, pharmaceutical firms, and university research centers to develop effective vaccines for the coronavirus all over the world (Copeland, 2020). Creating and maintaining effective distribution channels for the approved vaccines will heavily rely on the collaboration networks already in place.

- *Agile innovation*: The pandemic crisis has been the cause of human tragedy and economic damage. However one success story of the current experience with this pandemic is how organizations have learned to innovate fast in crisis, for which there have been many examples.
- *Exponential power of convergence*: In the time of the COVID-19 crisis, organizations and people are becoming extraordinarily creative to find new solutions. This is where the true exponential power of convergence is being found when different objects, technologies, disciplines, companies, industries, and talented people come together (Ip, 2020).
- *For the greater good*: To fight the common enemy, people, companies, health organizations and innovators are being united. The shared goal of people working together on innovative ideas to defeat the virus is for the greater good. It took 15 years to discover Spanish influenza virus (from 1918 to 1933), but it took only a few weeks to isolate the Covid-19 virus (Ip, 2020). This is the power of convergence of technologies, people and organizations all working together for a shared purpose.

Navigating the Post-pandemic Future with CI

The pandemic has caused enormous economic damages, not to mention people's emotional and social agony. However, it is time to reimagine what is possible if organizations and governments pivot effectively for the post pandemic period, as people's and organizations' behaviours have been permanently altered in many ways. The concept of CI could be of assistance in the pivoting process as follows:

- *Developing autonomous infrastructure for public health:* Scientific experts have warned that COVID-19 may remain for at least two years even if effective vaccines are found and applied. Thus, to protect from this and future pandemics, a smart

infrastructure should be developed to collect data in real-time and support decision making accordingly.

- *Mobilizing innovation at speed and scale*: Governments, business enterprises and nonprofits have learned that innovative actions must take place fast and at the appropriate scale.
- *Data visualisation:* The coronavirus crisis has taught people in some parts of the world to rely more on and trust more data. The White House Coronavirus Task Force presentations have attracted much attention as renowned scientists discussed the data-driven actions including the efforts to flatten the curve of the number of infected people. Unfortunately, that hasn't been the case in Bulgaria, where population is divided in their trust of the information presented by official governmental bodies. But all over the world the tendency for big data analytics to play a greater role in supporting the innovation ecosystems and collaboration platforms is present.
- *Flexible and resilient operating systems:* The pandemic has caused enormous disruptions on global supply chains. The vulnerability of the current systems will prompt the development of new nimble operating systems with contingent collaborative relationships (Bello et al., 2020).
- *Remote or "untact" services*: The pandemic has permanently altered people's behaviour in many aspects, from hand shaking to learning, exercise and fitness, socializing, traveling and entertainment. Many educational institutions may switch to virtual teaching as a major part of their services in the future. Likewise, people may start preferring "untact" (no contact) services in areas such as hospitality, retailing, and even healthcare (Lee & Lee, 2019).
- *High-touch digital transactions*: The pandemic has forced many consumers to switch their purchasing behaviour from high-touch personal experience to high-touch digital transactions. This behavioural change is not only for low cost consumer products, but also for high-end purchases such as jewellery, art, automobiles, or even real estate. Many digitally challenged senior citizens have learned to use online purchases, thus expanding the customer base for many retail businesses (Bello et al., 2020).
- *Change of priorities*: The unpleasant experience of the pandemic, not only for those who suffer from the disease or were deeply affected by its mortality, but also for ordinary people who have experienced social isolation for the first time, have given

them the chance to re-evaluate what is truly important in life and thus it has altered their economic and social behaviour.

Innovation strategies depend on the vision and competence of top management, industry type, the stakeholders and culture. Also, every organization has a value chain, a network of functions and activities for creation of added value. To sustain themselves, organizations must continuously innovate to improve their value chains through the various strategies and approaches, where CI can become another useful tool to achieve that goal.

Conclusion

We live in the digital age where changes are complex, turbulent and massive in scale. The compounding effect of numerous market forces has resulted in an environment of digital transformation. To survive and thrive in this new market, organizations must be agile and possess dynamic capabilities. In the face of unexpected crises, such as economic recessions, political uncertainties, climate change, wars, health issues (e.g., the global pandemic of COVID-19), organizations are put through the ultimate test of sustainability. To survive but also flourish in the time of crisis, organizations need to rely on their innovation capabilities. Sustainable innovation based on organised knowledge and collaboration has become imperative for enterprises, governments and non-profits.

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