Governance of Industry 4.0 Virtual Organizations [1]

Prof. Dr. Brane Semolič
LENS Living Lab, Slovenia,

Prof. Dr. Pieter Steyn
Cranefield College, South Africa

Summary

We live in a time of oversaturation with information and data that bombards us and is accessible at every step. This fact applies to all areas of human activity. It is information related to events in our immediate or broader social environment, the range of products and services, market trends, development activities, or something else. In addition to the benefits, such a mass of data and information also brings many problems. One such problem is their verification and, consequently, credibility, which brings a whole range of risks. These problems are not only present in laic environments, where various deceptions and misinformation of different social groups can occur. The problem is also present in professional circles, where such resources, professionally unverified in the broader environment, are used for various research and development needs and expertise, which are then used to guide the development activities of individuals, the economy, and society. This is already a problem that can cause a lot of confusion and deception in the development activities of the economy and society, which leads to the fact that the development efforts do not bring the expected benefits to all stakeholders. Moreover, they often introduce confusion and reduce the success of development efforts.

Due to the issues described, we decided to introduce in the first part some views and facts essential to understanding the phenomenon of Industry 4.0 and related issues that are the background for this article, where we are discussing the governance of virtual organizations.

Key words *Technology innovations, organizational innovations, behavioral innovations, partnering, collaboration, collaboration platforms, digital platforms, digitalization, Industry 4.0, virtual organizations, program and project management, collaboratist leadership, governance*

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1. Introduction

Technological innovation and economic development

In the first half of the last century, the Austrian American economist Schumpeter, who studied the theory of business cycles, wrote that innovations represent a crucial mechanism of economic change and development (Sweezy, 1943). This includes small, partial, or comprehensive changes in the observed economic environment. He illustratively called the most significant changes caused by technological discoveries, which cause changes in the techno-economic paradigm of the structure and functioning of existing economic-social systems, "gales of creative destruction." It is about the emergence of entirely new technologies and related products, activities, systems, and industries made possible by such revolutionary technological innovations.

In literature, we find several classifications of technological innovations, their size, and their impact on the economic and social environment.

An example of such a well-known classification is Freeman's classification, which distinguishes four types of innovation, namely (Monck C.& Co, 1988):

1. **Incremental innovations** – undramatic steady changes that occur continuously in most branches of industry and in services;

2. **Radical innovations** – discontinuous events that occur unevenly across sectors and through time;

3. **Technological systems** – combinations of radical innovations, coupled with organizational innovations across many firms. Such technology systems affect more than one branch of the economy and may spawn new sectors;

4. **Technological revolutions** – massive transformations associated with the diffusion of a new techno-economic paradigm involving radical innovations and new technological systems that have economy-wide applications and effects.

In Figure 1, we illustrate Freeman's breakdown of technological innovation types and their areas of influence.

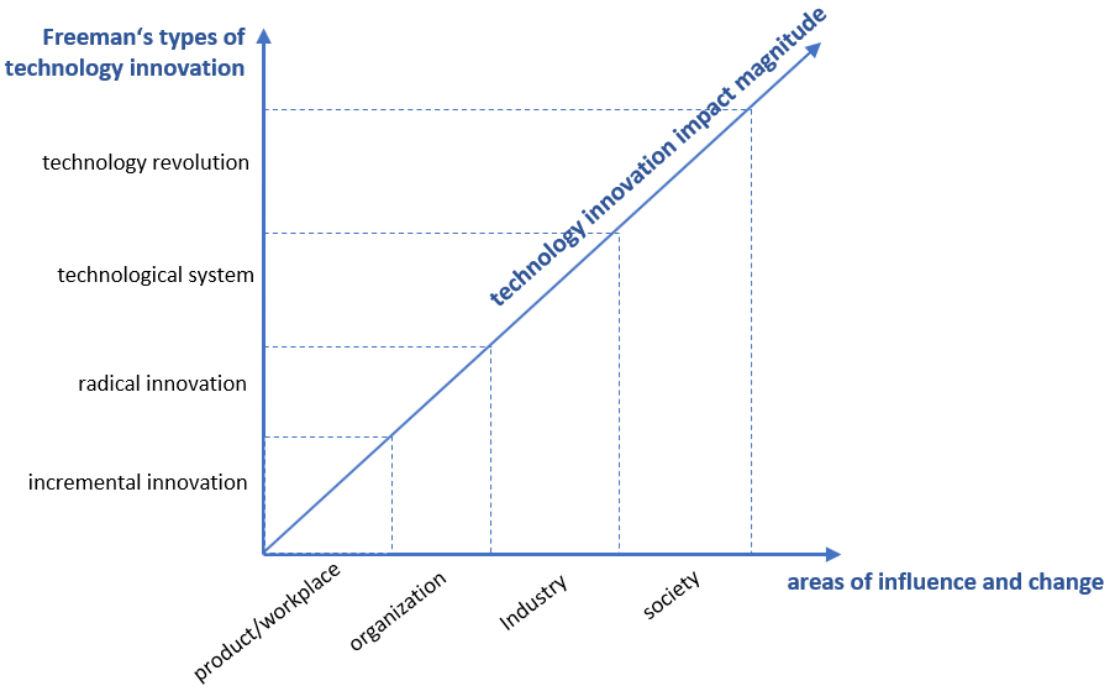

Figure 1: Freeman's types of innovations and areas of their influence

Undoubtedly, technological innovations represent the primary driving force or the "engine" of economic development. But what about the understanding of the term "technology"? What is the general definition of this phenomenon?

Galbraith offered one of the first generic definitions of the term “technology” in his book “*The new industrial state*,” published in 1967. He said that technology is the systematic application of scientific or other organized knowledge to practical tasks (Monck, Porter, Quintas, Storey and Wynarczyk, 1988). Technology is a universal phenomenon that can result in any knowledge area as its application for practical use. Technology presents the know-how of transformation of existing or new knowledge gained from research and practical experience, directed to producing new materials and products, installing new processes, systems, and services, or improving substantially those already built or installed. According to Mitchem, the term “technology” comprises the entire system of people and organizations, knowledge, processes, and devices that are related to the process of creating and operating technological artifacts, as well as the artifacts themselves (Pearson and Young, 2002). Galbraith's definition is universal, timeless, and generally applicable.

Interdependence of technological, organizational, and behavioral innovations

In most cases, the successful introduction of technological innovation requires changes in the workplace, business process, organizational system, or whole industry sector(s). It often requires upgrading existing or introducing new competencies of involved persons and, in some cases, even a change in the organizational culture of all stakeholders. Such magnitude of organizational-behavioral changes is present in technological innovations, types of technological systems, and technology revolutions. Figure 2 shows the connection and interdependence of technological innovations with organizational and behavioral innovations and the changes they enable. In some instances, they are even a condition for their successful exploitation.

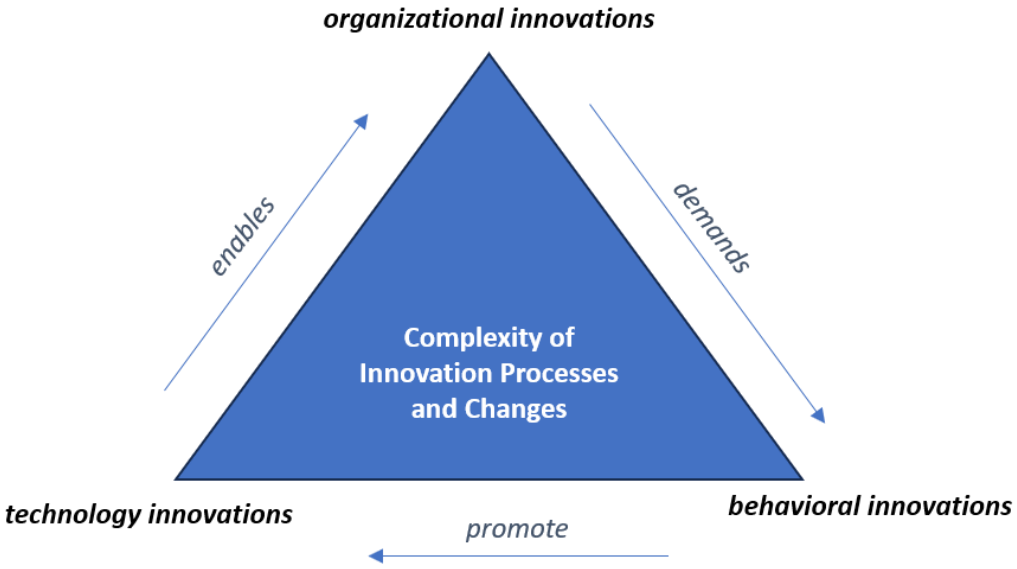

Figure 2: Complexity of innovation processes and changes

Organizational innovation refers to organizational changes that technological innovation requires or enables. It concerns changes related to business goals and relations, organizational systems and structures, business processes, and management systems. Developing and introducing technological and organizational innovations requires appropriate behavioral competencies and skills from all involved actors. These behavioral innovations provide adequate knowledge, skills, and energy for the planned changes and the realization of the expected benefits for all stakeholders of the changes in question.

Technological innovations and the industrial revolution

Since 2011, much has been written and talked about Industry 4.0. Industry 4.0 should already be succeeded by Industry 5.0, which has recently been advocated and promoted by some politicians with the support of a specific part of the profession. Some are already announcing Industry 6.0. Are we already there?

The current authors believe the "industrial revolution" is synonymous with the "technological revolution."

To clarify concepts and context requires briefly look at the chronology of the technological revolutions of the modern industrial age. The history of modern industrial and, thus, technological revolutions began with the beginning of the industrialization period, with the advent of steam engine technology, which triggered the changes of the first industrial revolution. The second industrial revolution was initiated by technological innovations in the field of electricity, the third by technological innovations in computing, and the fourth by the emergence of Internet technologies. All cases involve dealing with "***critical technologies***"[2] that caused and enabled technological and social changes characterized by the term technological revolution.

The new techno-economic paradigms evoked and made possible by the critical technologies of the mentioned technological revolutions generated a series of new related technological innovations, which enabled the introduction of pivotal techno-economic and societal changes. All this required new competencies as well as professions, changes in the functioning of markets, changes in organizational culture, and changes in the functioning of the entire society.

The previously mentioned ideas of Industry 5.0 and 6.0 are not based on the appearance of new scientific discoveries and related technological innovations of the "technological revolution" type. They derive from the use of Industry 4.0 technologies, which provide opportunities for organizational and behavioral innovation and change, which the advocates of Industries 5.0 and 6.0 understand as the "new" industrial revolutions that follow Industry 4.0.

Proponents of the Industry 5.0 concept claim that, in this case, the focus is on employees and their benefits, on "machine-human" collaboration as the center that uses the new

[2] Critical technology - A system or technology that is deemed by the entity to be of particular importance (PCI Security Standard Council, 2024)

technologies of Industry 4.0. Proponents of Industry 6.0 believe that this is the next level of connectivity and integration between systems.

The current authors believe that the described cases are not new industrial revolutions. They only deal with the organizational and behavioral changes caused or needed by Industry 4.0's technologies or present its development phase.

The interpretations described indicate a misunderstanding of the concept and phenomenon of "technological revolution." Technology is invented to improve the satisfaction of existing human needs or to generate entirely new needs resulting from scientific and technological development and the artificial creation of new markets for new needs that potential users have not known until now. In today's world there are many technological artifacts that create and foster entirely new needs and markets.

Every technological innovation aims at existing or future human needs. As a result, a separate treatment, as proposed by the authors of Industries 5.0 and 6.0, is pointless. Appropriate technological, organizational, and behavioral literacy is necessary for all stakeholders of transformation projects and programs, which must be governed, managed, and led by international project management and business excellence standards.

2. Technological and organizational innovations of Industry 4.0

Technological innovations of Industry 4.0

The beginnings of Industry 4.0's transformation and changes date back to the first half of the 90s of the last Century, when the TCP/IP protocol was introduced, making connecting computers to a global network possible. This was the birth of the revolutionary technology, the World Wide Web (WWW), today's Internet.

The WWW was introduced to the public in 1991 by Tim Berners-Lee, while he was working at CERN (the European Organization for Nuclear Research) in Switzerland. He developed the first web browser and web server software, laying the foundation for the web as we know it today (ChatGPT, 2024).

In April 1994, NETSCAPE launched the Navigator browser, and "out-of-the-box" speculations became reality. The hitherto arcane communications platform of the

INTERNET suddenly became available to all, and, almost overnight, we began to feel the effects of an internetworked world (Tapscott, 1998).

The emergence of INTERNET and NETSCAPE technologies triggered the development and creation of a series of web browsers. Today, the greatest popularity and market coverage is achieved by the GOOGLE web browser, which was introduced in 1998 by computer experts Larry Page and Sergey Brin, PhD students at Stanford University and co-founders of the company of the same name (taken from various online sources, 2024). INTERNET technology provided a platform and boost for new technology innovations based on the use of this technology. These Industry 4.0 technology innovations can be divided into three interrelated groups (Semolič B. & Semolič L, 2019), namely (Figure 3):

1. **Virtualization technologies:** Internet technologies, cloud computing technologies, virtual reality technologies, blockchain technologies, cyber security technologies,

2. **High-performance communication technologies:** technologies of the Internet of Things, technologies of cyber-physical systems, technologies of high-performance communications, and

3. **High-performance computing:** high-performance computing technologies, artificial intelligence technologies, machine learning technologies, big data analytics technologies.

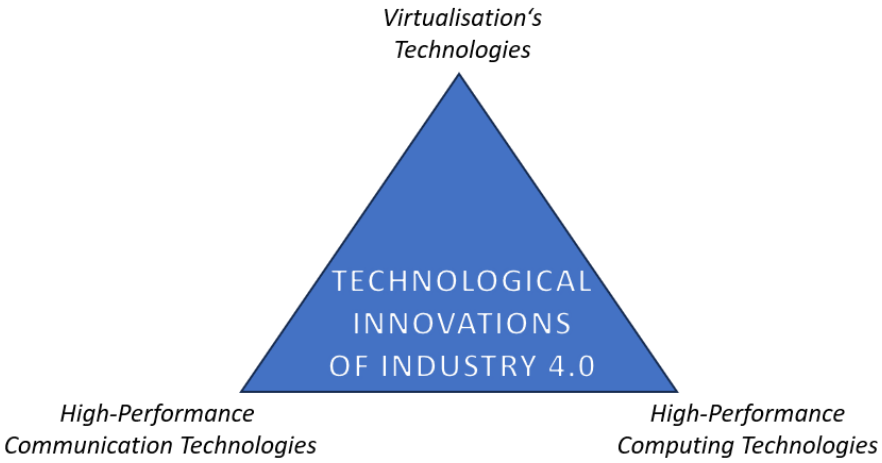

Figure 3: Technological innovations of Industry 4.0 (Semolič B.& Semolič L.,2019)

The mentioned technologies represent the fundamental platform of revolutionary Internet-based technologies, which enable the development of new forms of satisfying the needs of spatially dispersed operations with long-distance collaboration, co-creation, and the development of business-social networks.

The above-mentioned generic technologies enabling Industry 4.0 stimulated and accelerated the development of a series of new radical technological innovations and systems of Industry 4.0, such as 3D printing technologies, new collaborative robotic systems, advanced automation technologies, etc.

Undoubtedly, the Internet was the trigger and critical technology for creating and developing Industry 4.0. Internet-based technologies established a technological platform that enables the development of revolutionary organizational innovations and improvements. Until then, the existing technologies of connecting computers were limited to local area networks of organizations (LAN) and inter-organizational networks (WAN), intended for a narrow part of business users. The revolutionary technology of the Internet has enabled the development of technologies for connecting all computers, things, organizations, and people to the global network. It enabled the development of new revolutionary forms of networking of things, people, and organizations (Figure 4) and entirely new services, business models, and societal changes (Semolič, 2002).

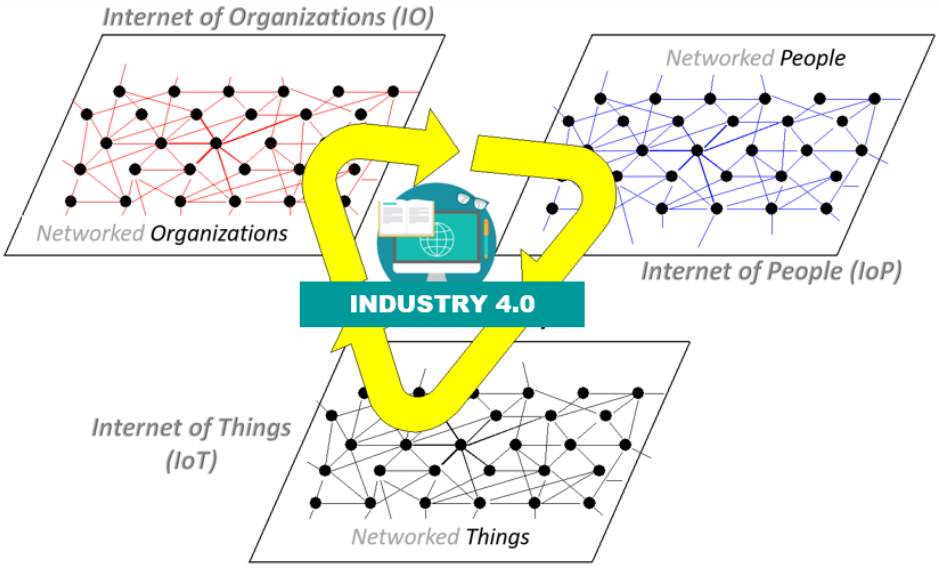

Figure 4: Internet of everything (updated source: Semolič B.,2002)

Organizational innovations of Industry 4.0

Shortly after the presentation of Internet technology, experts recognized the importance of its mission and strategic potential. One such beginning is represented by the two-year partner research-advisory program "Blueprint to the Digital Economy" of the consortium of partners "Alliance of Converging Technologies" in 1994 (Tapscott, 1998). Thirty-five companies and government organizations sponsored the program. Its primary purpose was to study the impact of new revolutionary technology on creating and developing new business models.

In addition to the mentioned “Digital Economy”, the term “New Economy” also began to be used for this new industrial revolution era (Kelly, 1998). Kelly believed that the main characteristics of the new economy are that it is global, prioritizes intangibles such as information, connections, and ideas, and is closely interconnected.

One of the main characteristics of new revolutionary technologies is their ability to enable the mutual networking and connection of things, people, and organizations and the virtualization of business. Here, it is necessary to distinguish two otherwise very connected and inseparable phenomena of business virtualization (Semolic B. & Semolic L., 2019). The first refers to the virtualization of “*technological systems”*, while the second relates to the “*organizational systems”* of a virtual organization.

“***Virtualization of Technological Systems (VTS)***” refers to access and operations of spatially dislocated computers, computer programs, technological systems, equipment, databases, and networks.

The “Virtualization of Organizational Systems (VOS)” refers to business models of virtual organizations, their spatially distributed partnering organizational and inter-organizational collaboration structures, and the virtualization of business processes, workplaces, and managerial systems.

If the technologies of the third industrial revolution enabled organizational innovations in serial and mass production, the technologies of the fourth industrial revolution enabled the advent of new business models based on networking and the development of virtual dynamic organizations.

In the era of Industry 3.0, the focus was on cost efficiency and business excellence. However, in the era of Industry 4.0, agility, flexibility, the next level of customization and servitization, and capabilities for constant innovation and adaptation were added. The

volatile markets of Industry 4.0 generate an increasingly chaotic business environment, which demands the ability to constantly adapt and introduce improvements and novelties. The latter applies to all large, medium, small, and micro-sized organizations.

New technologies that enabled the virtualization of organizational operations, new services, and changed market needs triggered a series of scientific research that brought a new theoretical organizational knowledge base for a series of organizational innovations in practice. Examples of new organizational theories are the theory of network organizations, the theory of virtual dynamic organizations, the theory of open innovation, the theories of digital and innovation ecosystems, the theories of collaboration platforms, the theory of dynamic capability, the theory of servitization, the product life-cycle management theory, the theory of ambidexterity, etc.

VOS can be grouped into three interwoven and connected groups of organizational-technological innovations (Semolič B & Semolič L, 2019), namely (Figure 5):

1. ***Virtual collaborative workplaces (VCW) –*** hybrid work in an organization and/or remotely, where work activities are organized and carried out in collaboration between human and cyber-physical resources,

2. ***Virtual dynamic organizations (VDO) –*** a permanent or temporary organizational form of spatially dispersed own organizational units or/and partner organizations with common business interests, missions, goals, and integrated business-technological processes. Its main characteristics are adaptability, agility, specialization, better access to resources, direct connection to the market, lower costs, and greater efficiency and effectiveness,

3. ***Virtual communities and collaboration platforms (VC&CP) –*** virtual communities are groups of individuals with common interests who exchange information and ideas and co-create joint initiatives. In doing so, they use various public or private thematic digital platforms of partner collaboration organized by individuals, informal interest groups, organizations, or groups of organizations.

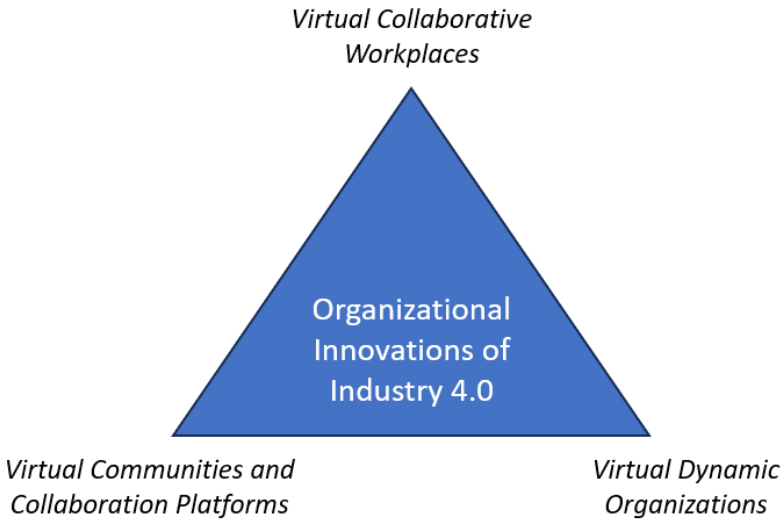

Figure 5: Organizational innovations of Industry 4.0 (Semolič B.& Semolic L.,2019)

New technologies enable the individualization of products and services and the high adaptability and agility of production processes to meet individual clients' needs. Such a way of working has caused a renaissance and a significant increase in various forms of project-based production and the creation of new forms of accompanying service activities. An increasingly robotic and automated operation, supported by the latest technological tools and artificial intelligence, is slowly displacing human work from routine and repetitive tasks. Simultaneously, the growth of various new types and forms of development jobs of inter-organizational collaboration, mainly of a program-project nature are recorded. This kind of development collaboration and partnership is becoming one of the critical factors in the development ability and success of Industry 4.0 organizations.

The labor market is faced with changes and an increase in temporary and project-based forms of employment. In most cases, the demand for this type of work is insufficiently regulated by existing legislation, which poorly protects the interests of employees and employers. In any case, this is one of the areas where we should expect organizational innovations and changes soon.

Science is a critical factor and driver of the development of the economy and society of Industry 4.0. Business environments with more significant research and innovation potential are more competitive and successful. Global surveys show that the size of organizations', regions', and countries' investments in research and innovation is closely correlated with their international competitiveness.

Research and innovation activities no longer take place solely in the traditional research environments of large R&D organizations, universities, and companies. These activities are also present in today's advanced medium, small, and micro-sized organizations, which successfully compete with the big ones using enabling technologies and collaborative business models of Industry 4.0.

3. Governance of Virtual Organizations

The Advent of Virtual Organizations

The emergence of demands for more flexible and agile organizational forms of organizing business activities is not new. New concepts appeared in the late 1980s and 1990s, such as flexible project-organized network organizations connected to business partners via LAN and WAN computer networks (Semolič, 1992).

Semolič & Kovač (2009) argue that one of such first contributions in dealing with the topic of virtual companies was a book by title “The Virtual Corporation” by William H. Davidow and Michael S. Malone, published in the 1992. Yet, the dematerialization of the products, processes and workplaces in the organization was set in the focus of the field experts already in the 1985 (and in 1987, 1994) by Abbe Mowshowitz. At the base of the established frameworks, the authors Venkatraman and Henderson developed the three gradual models of the business virtuality in 1998. According to their views the virtual organizations differ from other organizations by specific abilities and by their “virtual attitude of thinking”. The mentioned abilities and virtual attitude of thinking are expressed by:

- products and services that are presented to the customers “virtually”, or are “virtually” consumed (“virtual encounter”);
- supply processes among the organizations and by the processes inside the organizations, where the continuous processes of searching the synergistic links are carried on (“leverage-effects” and “virtual sourcing”);
- knowledge in possession of the organization or among the organizations who, at different levels, connect in a flexible and non-bureaucratic way (“virtual expertise”) (Venkatraman, Henderson, 1998).

The emergence of the Internet and the related new revolutionary technologies of the Internet of Things and cyber-physical systems gave a tremendous boost to the existing and the development of entirely new forms of business connection and networking. New technologies provide opportunities for the development of flexible virtual organizations that, with the help of a cyber-virtual environment, connect and use the resources of their own and partner spatially dispersed organizations.

Virtual Organization Characteristics

In the literature, these kinds of organizations are often described as a network of organizations (boundless organizations). These are dynamic and network-connected partnering organizations (virtual organizations) linked via inter-organizational information platforms that support partnering operations and projects in the given areas of pre-agreed collaboration interests.

Most of the existing studies point out that virtual organizations are a temporary consortium of partners from different organizations establishes to fulfill a value-adding task, for example a product or service to a customer (Duin, 2008). According to Rabelo and Pereira-Klen (2004) virtual organizations are temporary alliances between organizations to share skills or core competencies and resources to better respond to new collaboration opportunities (Loss et al., 2008). This way, virtual organizations represent cooperation between formally non-connected organizations or persons who establish vertical or horizontal links and present themselves to the customers of their products or services as a single association. Apart from the professional literature concerning virtual organizations, emphasis is also given to information and communication technology and the absence of central control functions. (Mohrman, Galbraith & Lawler III., 1998; Dessler, 2001; Pettigrew et al., 2003; Vahs, 2005, Semolič & Kovač, 2008 and 2009).

As alluded to earlier, revolutionary Industry 4.0 technologies create opportunities for small, medium, and micro-sized organizations to be visible and active in the global market. Such newcomers face challenges of globalized competition and competing with large organizations, which have traditionally dominated technological development and world markets. Specialization, outsourcing, and innovative business models of collaboration with value and supply chain business partners solve the problems of stiff competition and limited resources. These are the main reasons why, in addition to temporary forms of business collaboration, more and more permanent forms of such business partnerships have appeared recently.

Figure 6 shows the forms of collaboration between business partners, considering the areas of collaboration and the duration of such partnership.

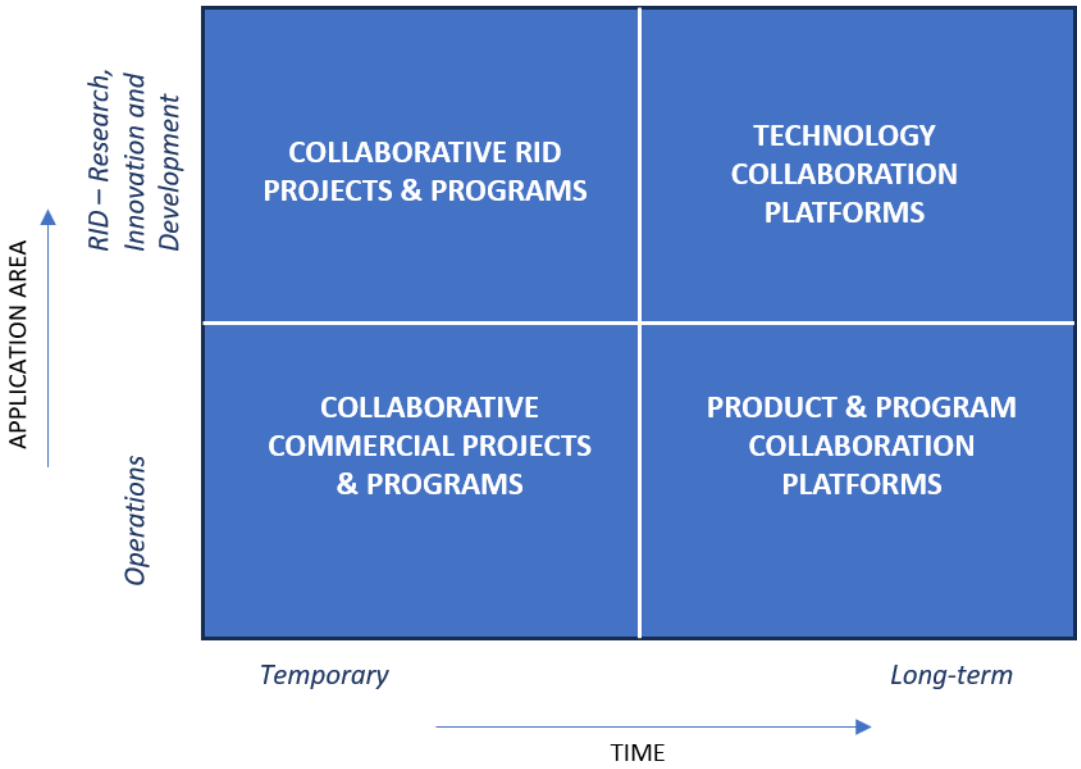

Figure 6: Forms of partnership collaboration in virtual organization

Short-term forms of collaboration between industry partners appear mainly in joint partnering research, innovation, and development projects and programs. The same applies to collaborating with organizations that come together to execute large or technologically complex commercial projects or programs.

The business models of various long-term "***Thematic Collaboration Platforms (TCP)***" represent emerging forms of flexible virtual organizations. Their primary purpose is the realization of mutually agreed purposes and benefits between collaborative partners. These purposes may relate to joint products, technologies, development, marketing, or any other interest in such a partnership.

TCPs' working environment is represented by "***Virtual Digital Platforms*** (VDPs)," which provide digital ecosystems for implementing remote collaboration and operations. VCPs

provide a communication backbone, a set of different virtual collaborative workplaces, and digital tools for managing, coordinating, and implementing agreed-upon activities.

Governance of Virtual Organizations

Virtual organization governance is defined as a system by which virtual organizations are directed, coordinated and controlled. Boards of virtual organizations' co-founders and partners are responsible for their coordination and governance. The governance role is to appoint areas of collaboration interests, approve a virtual organization's business model, appoint its coordinator, supporting boards, and auditors, and ensure an appropriate governance structure and procedures.

Governance, coordination, management, and leadership of virtual and its partnering organizations are closely interrelated. Strong interrelations exist between the governance, coordination, management, and leadership processes of both types of organizations incorporated into a partnering virtual organization.

Hilb defines corporate governance of virtual organizations as a system “by which companies are strategically directed, integratively managed and holistically controlled in an entrepreneurial and ethical way in a manner appropriate to each particular context” (Hilb, 2006).

Governance processes occur in the areas and levels of pre-agreed inter-organizational collaboration interests and responsibilities within partnering organizations. The complexity of governance processes demands a clear distinction and mutual harmonization.

The critical governance processes in forming virtual organizations are related to defining the virtual organization's goals, form, and roles of collaborative partners.

The strategy of virtual organizations must stem from the strategies of the involved partnering organizations.

When joining a virtual organization, the owners and management of individual partnering organizations must ask themselves the following questions (upgraded from Semolič, Kovač, 2009):

1. What are the primary expectations, purposes, strategic goals, and strategies of forming a new or joining an existing virtual organization?

2. What advantages, disadvantages, and risks does this collaboration imply to their organizations?
3. What are the benefits and advantages of such a type of collaboration?
4. What role will our organization have in a proposed virtual organization - founding partner, R&D partner, program/product partner, technology partner specialist, project partner, etc.)?
5. Trust between potential partners?
6. Previous experiences from similar initiatives?
7. What are the alternatives?

When forming virtual organization, special attention must be paid to selecting partners. The first step in this process is to know and understand the partners' strategic intentions and expectations. A business partner's review and understanding of the partner's background and motivations for collaboration are critical for success. This valuable information can spare us from future unpleasant surprises. In practice, we have cases where certain organizations are joining such virtual organizations solely with the motivation of acquiring information on their partners and because of their short-term benefits. This enables them to have greater control, price pressure, access to technologies, external funding sources, etc. The key to partner selection is to know their strategic implications for joining (Mohrman, Galbraith & Lawler III., 1998; Semolič & Kovač, 2009).

Having chosen the partners, the founding organization(s) must then select forms of virtual organizations and reach an agreement on the role of the organizations (conclusion of a short or long-term collaboration agreement). An organization's role depends on its specialization, the ability, purpose, and goals of joining a network. Primarily, we speak of the decision in the form of the legal status and ways of implementing an integrative role, as well as a definition of the place and role of other companies in the network. The primary criteria for the selection of a coordinating role in a virtual organization are (Mohrman, Galbraith & Lawler III., 1998):

1. Knowledge of the entire process or the chain of added value,
2. Experience,
3. Ability to gain the necessary resources for the operation of a virtual organization,
4. Disposable resources,
5. Credibility of the organization,
6. Key factors or abilities of individual organizations,
7. Management resources with the required expertise and experience,
8. Readiness to assume the role.

It is appropriate to stress that the required collaborative efforts in governing, coordinating, and managing the implementation of integrative processes are often underestimated and not adequately conducted (Schräder, 1996; Semolič & Kovač, 2009). Therefore, it is significant to properly select empowered representatives of partnering organizations for the collaborative efforts, governance bodies, coordinators of collaborative tasks, managers, and other personnel who work in such inter-organizational virtual organizations.

Krystek, Rede & Reppegather argue that coordinators who harmonize, monitor, control, organize, and guide virtual organization collaborative processes in virtual organizations must possess the following properties and skills Krystek, Rede & Reppegather, 1997):

1. Integrative abilities,
2. Goal-oriented management control,
3. Sensitivity to various organizational cultures,
4. Competencies in the field of virtual networking,
5. Participation,
6. Ability to motivate,
7. Restriction of constructive conflict management,
8. Communicative and representative skills,
9. Controlling of information management.

The same authors as (also Reiss, 2000) argue it is crucial that individuals who assume critical positions in virtual organizations have the following properties and skills:

1. Professional and functional knowledge,
2. Communication skills,
3. Cultural adaptability,
4. Adaptable and constructive conflict management,
5. A desire to participate,
6. A need for horizontal and lateral professional and personal development,
7. Entrepreneurship,
8. Independence and a sense of responsibility.

Mature leadership with well-orchestrated governance, coordination and management of Industry 4.0's virtual organizations to the following properties and skills are critical:

1. Technology literacy,

2. Digitalization literacy,
3. Innovation management literacy,
4. Understand the integrative complexity of Industry 4.0 collaborative business cases,
5. Management of collaborative projects and programs,
6. Ability to organize, coordinate, and lead work in virtual collaborative environments,
7. To manifest collaborative leadership and foster a collaboration culture.

Selection of individuals that hold key positions in a virtual organization reduces conflicts, which are one of the most sensitive areas of management. There are many conflicting areas in virtual organization. This is why one of the most important managerial goals is to lay the principles, means, and instruments to resolve any possible future conflicts while forming a virtual organization. One must clearly set the procedures and levels of conflict solving (Semolič & Kovač 2009).

Governance of Collaborative RID Projects

The governance of virtual organizations using the example of collaborative research, innovation, and development projects (RID Projects), whose popularity has been rising in recent years, especially in the EU will be illustrated.

A new conceptual design and development of innovative industry 4.0 applications, including their full scale-up industrial implementation, is a complex project that requires the multidisciplinary collaboration of various professions, users, clients, and support services from different organizations and business ecosystems.

The complexity of Industry 4.0's transformation RID projects requires the mix mentioned above of highly qualified, usually limited resources, especially in small and medium-sized organizations. Outsourcing external experts, contractors, and other resources is essential in such cases. Small and medium-sized organizations face even more significant problems when they want such projects to increase global competitiveness by searching for and developing entirely new technological designs and business models. These types of projects also have substantial financial risks that are usually too high for the possibilities of small and medium-sized organizations.

In most cases, the partnership of several organizations is the only solution to overcome the described problem. It is a "win-win" situation. By partnering and collaborating, such organizations can secure "the window" to new cutting-edge technologies and new "first on the market" business solutions.

Therefore, "*Collaborate or not collaborate?*" resembles Hamlet's decision-making dilemma when modern organizations examine their Industry 4.0 research and innovation needs and potential implementation strategies for acquiring new technological and business applications.

This dilemma is not new. Many research outputs exist in a global knowledge base and provide insights into how cooperation or collaboration[3] is beneficial in certain situations. Such an example is the book "*The Evolution of Cooperation*", written by Robert Axelrod (Axelrod, 1984), who explored decades ago the conditions under which cooperation emerged in a world of egoists without a central authority. Axelrod and other authors discovered that collaboration occurs when all participating entities can benefit from such behavior to fulfill their individual needs.

What are the critical factors for the decision to enter RID projects with two or more partnering organizations, and when can potential project partners benefit from such behavior? The answer is straightforward. Organizations can benefit when they lack internal innovation potential and resources to realize desired strategic business goals. The organization must find the proper balance between its strategic interests and expectations and the interests of other participating partners, negotiate and find joint interests, find co-solutions, and co-create a culture of equality and trust with all participating partners. This can be seen easily in theory; however, it is usually a very demanding and challenging task in practice.

Governance of such collaborative RID projects is a technically, organizationally, and behaviorally highly complex business endeavor.

Figure 7 illustrates the complexity of the project organization in the imaginary RID project "I" business case. Partner organizations must simultaneously organize the management and coordination of the implementation of joint activities and the management of project activities in their organizations, which represent the introduction of jointly developed solutions in their environments. Project activities at both levels must be well governed, coordinated and managed.

[3] Today, we commonly use » collaboration« instead of »cooperation. « Collaboration occurs when two or more independent entities decide to work on joint businesses as equal partners.

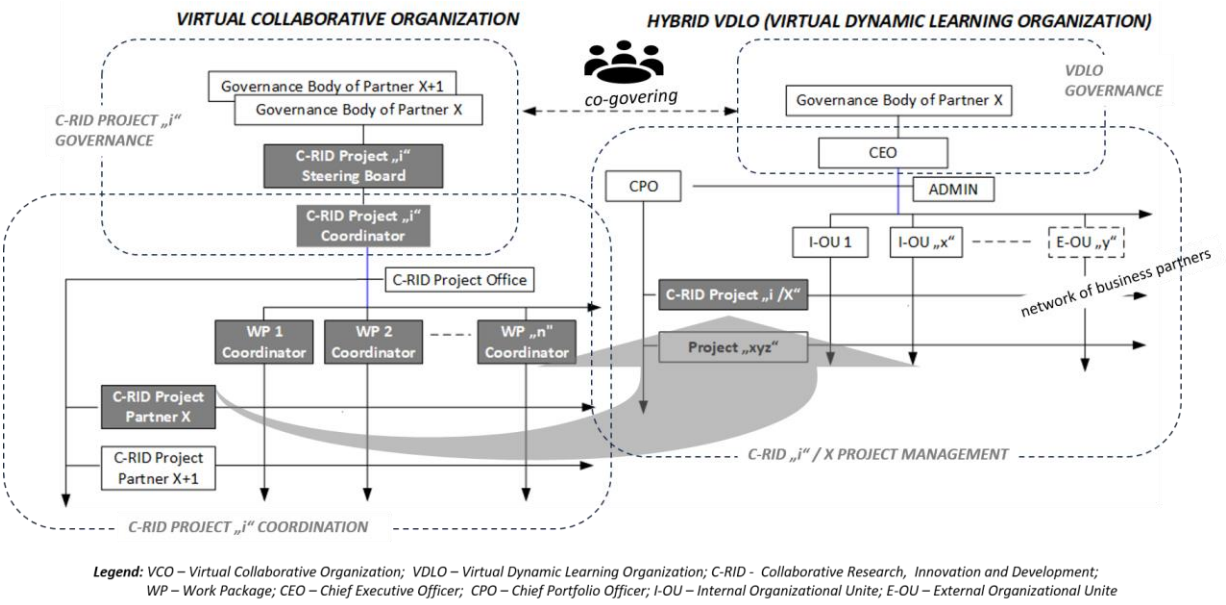

Figure 7: Complexity of the collaborative RID project organization

Virtual organization (VO)		Partnering Organizations "X+1"	
Collaborative RID Project "i" (RID-Pi)		Hybrid VDLO[4] "X"	
Functions	Collaborative Tasks	Functions	Partner "X" Tasks
RID-Pi Co-governance	Jointly identifies strategic opportunities - expectations and related RID-Pi integrative goals and objectives	Organization "X" Governance	Assessment of the RID-Pi initiative strategic alignment with corporate strategies; strategic decisions and approvals; appointment of an authorized representative for the needs of RID-Pi co-governance
	Jointly defines project partners' RID-Pi scope, limitations, and responsibilities and provides leadership support.		Defines and approve corporate internal RID-Pi /X strategic expectations, goals, objectives, and scope of organizational engagement
	Jointly defines decision-making processes and output metrics controlling procedures		Enables required resources for the RID-Pi /X implementation

[4] VDLO – Virtual Dynamic Learning Organization – for more information see Chapter 3

	Jointly enables resources provided by project partners and their associates		Provides RID-Pi /X sponsorship, conflict management and leadership support
	Jointly defines rules of collaboration and resolves potential conflicts and disputes		Defines and approve RID-Pi /X internal output metrics, with internal controlling procedures
	Jointly monitoring and controlling project's results		Monitoring and controlling of RID-Pi /X results
RID-Pi Project Coordination	*Used the ISO 21500 standard guidelines, adapted to the needs of coordination of partnering-collaborative RID projects*	RID-Pi /X Project Management	*Used standard guidelines of ISO 21500*

Table 1: Two interrelated governance domains of the Collaborative RID project "I" (RID-Pi) and partnering organization "X" with its internal extension project RID-Pi / X

Table 1 presents two typical interrelated governance domains, on the observed example of the Collaborative RID project "I" (RID-Pi) and the partnering organization "X" with its internal extension project RID-Pi / X. In such collaborative RID projects, new technologies and business solutions are typically co-innovated with partnering organizations as part of jointly performed project activities. The jointly achieved deliverables are then further adapted and integrated into the operations of partnering organizations according to their specific needs.

Collaborative RID projects require high motivation and mutual trust from all participating organizations and well-coordinated governance and management processes in the domain of the collaborative RID project and the domain of participating partner organizations.

Adequate coordination and support for joint activities and the management of individual organizations' specific additional internal activities are necessary to fully implement developed innovations for the final benefit of participating partners.

Successfully implementing RID projects requires establishing an appropriate project organization within both project implementation domains at the collaborative RID project level and each partner organization's levels. In the case of partnering organizations with many projects are recommended organizational solutions such as introducing a Chief

Portfolio Officer (CPO), which coordinates the portfolio of the organization's projects and, in this way, helps the on-time implementation of planned RID project activities.

Figure 8 shows the LENS Living Lab's internal organizational standard as an example of the collaborative RID project's governance processes.

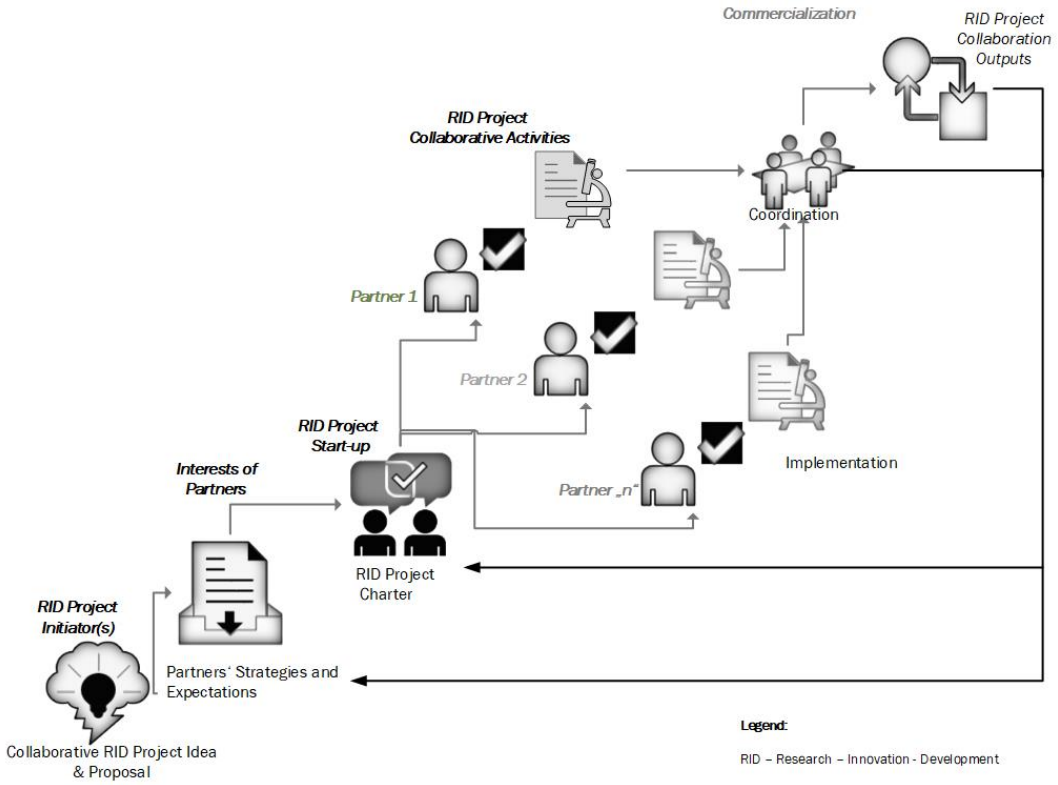

Figure 8: LENS Living Lab's governance process example of the collaborative RID project (Semolič B. & Semolič L., 2020)

Governance, management, and leadership of collaborative RID projects, programs, and portfolios represent one of the critical vital areas of integrative competencies and skills. These are preconditions for successfully implementing Industry 4.0 transformation processes and changes. Practice and research outputs show that this field is often poorly represented and present. This fact is indirectly proven by the large percentage of unsuccessfully implemented digital transformation projects, which fail to achieve the expected results in 70-85%[5] of cases.

[5] The research was performed by the use of ChatGPT, 2024

The problems mainly relate to the absence of proper governance, management, and leadership of partner projects/programs. In most cases, the project/program scopes are not adequately strategically and holistically addressed, are poorly coordinated in content and organization, and have insufficient respect for interdisciplinary and organizational diversity. Often, they neglect the participants' required integrative qualifications and fail to consider the differences in the organizational cultures of the involved partners. Finally, such projects/programs frequently suffer because of poor leadership, governance, coordination, management, and trust between all involved parties.

Leadership is one of the components of behavioral competencies that is critical for the success of any form of virtual organization. The key to the success of virtual organizational ventures is the leadership engagement of its initiators, the leadership and management support of the partnering organizations, the leadership of virtual organization leading coordinators, virtual organization teams, and their supporting service organizations.

4. Leadership of Virtual Dynamic Learning Organizations

The research of Lawrence and Lorsch (1967) with respect to successful and unsuccessful organizations in three industries is very significant for the Industry 4.0 situation. They hypothesised as follows:

- Overall organizational performance was dependent on the degree of differentiation in subsystems consistent with environmental requirement and the degree of integration between subsystems consistent with the environment.

- When the environment requires high differentiation and integration, integrative devices (task-groups, planning departments, cross-functional teams) will emerge.

They concluded that as environmental ***complexity increased***, successful organizations exhibited ***higher degrees*** of both ***differentiation and integration***. This means that these organizations maintained an effective balance. In contrast, unsuccessful organizations suffered from an imbalance of too much differentiation and not enough off-setting integration. The lesson learnt was that managers need to maintain focus on the balance between growing and increasingly differentiated organizations on the one hand, and on the other hand the evolution of ever better means of ***integration and coordination.*** Moreover, they discovered that the ***more differentiated*** an organization becomes, the

more difficult it is to achieve ***integration***. From this one can conclude that managers of modern-day complex organizations need to strive constantly and creatively to achieve ***greater integration.*** The above aspects profoundly apply to today's virtual organizations operating in the Industry 4.0 economy.

From the conclusions drawn by Lawrence and Lorsch (1967), it is patently clear that as complexity and risk increase in the Industry 4.0 economy organizations of today, the more they will revert to the ***cross-functional structures and paradigms*** of portfolio, programme, and project management. Lawrence and Lorsch (1967) propose integrating mechanisms such as a formal hierarchy; standardising the organization's policies, rules and procedures; cross-functional teams; and departmentalisation. The research was done during the 1960s but the findings are profoundly applicable to the Industry 4.0 situation of forming networks of partner organizations.

Their conclusion regarding environmental complexity and the need for ***higher degrees of differentiation and integration*** under those circumstances holds true for virtual networks of partner organizations of all forms. It is interesting to note that it was during the mid-1960s that the first ever articles on 'program management' by Dr Russ Archibald appeared, followed by the publication of his textbook on the subject in 1976. By then the principles and ideas related to matrix management were known, hence the mention of cross- functional teams as integrating mechanisms by Lawrence and Lorsch. The above-mentioned were the forerunners of cross functional project, portfolio, program, supply chain, and value chain structures and paradigms used in modern day virtual dynamic learning organizations and virtual networked organizations initiatives.

According to Semolič and Steyn (Sept 2017) the world economy is gradually moving forward from the Industry 3.0 economy business environment where optimization and automation of an organization's resources were the key issues. Overall competitiveness in the Industry 4.0 enterprise does not depend solely on innovation, optimisation, and competitiveness of its resources, but ***collaboratist leadership*** led total inter-organizational value chain innovativeness and supportive partner technologies, products, services, and systems. With the aid of partners, organizations are co-creating innovative inter- organizational value and supply chains that operate in local, regional, national, and international collaborative business ecosystems. Organizational development (OD) has entered a brand-new phase. The strategic transformation and change of Industry 4.0 organizations are driven by modern information, communication and technology principles and practices that allow for the creation and integration of new horizontal supply, value chain, and virtual network partner business models.

Virtual value chains shape the organization into dynamic and strategically relevant collaborative value driven activities, performed by carefully selected partner organizations. A competitive edge is gained via collaboratively performing the strategic activities more effectively and efficiently. This approach calls for carefully planned and executed governance principles supported by ***leadership excellence*** and a clear understanding of program management principles by all partner organizations in a virtual network.

Steyn and Semolič (March 2017) aver that Industry 4.0 businesses are flourishing in regions and countries where organizations are armoured with adequate competences, available resources, ***super-transformational collaboratist leadership,*** sound corporate cultures and sustainable regional support. Modern Industry 4.0 virtual organizations are also searching for new methods to create favourable business conditions by providing adequate supporting services. It is evident that technological changes are not enough to achieve expected results, as was the case in the past.

The Industry 4.0 economy has seen dynamic capabilities theory emerging as a profoundly essential element in creating performance rich virtual dynamic learning organizations (VDLOs) to replace dysfunctional bureaucratic entities. Moreover, an entity needs to have transformed to a VDLO to be successful as an initiating partner or partner organization of a virtual network arrangement. Customer expectations, product and service enhancement, collaborative innovation, and organizational forms are aspects profoundly affected by the new economy. Collaborative innovation is of paramount importance for increased competitiveness, as well as product / service, and concomitant process improvements that inspire new business models and organizational paradigms and structures. To guarantee success it is important having ***super-transformational collaboratist leaders*** at the helm (Steyn and Semolič, May 2020).

Dynamic capabilities include difficult-to-replicate organizational capabilities required to adapt to changing customer and technological opportunities. They also embrace the entity's capacity to shape the ecosystem it occupies, develop new products and processes, and design and implement viable business models. These capacities support an entity's capacity to successfully innovate and capture sufficient value to deliver superior long-term financial performance. An organization's success profoundly depends upon the discovery and development of opportunities; the effective combination of internally generated and externally generated innovations; efficient and effective technology transfer inside the entity; the protection of intellectual property; the upgrading of "best practice" business processes; and the invention of new business models.

Dynamic capabilities represent a strong break with Porter's Five Forces. The 'environmental' context recognized for analytical purposes is not that of the industry, but that of the business 'ecosystem', which can only be achieved in organizations blessed with exceptional ***Industry 4.0 collaboratist leadership*** (Semolič and Semolič, Aug 2021). Dynamic capabilities are grounded in evolutionary theories of economic change, whereas Five Forces is grounded in the Mason-Bain paradigm of industrial economics (Teece, 2014). Teece's argument is that whereas according to Porter the essence of strategy formulation is 'coping with competition', in dynamic capabilities the essence of strategy involves selecting and developing technologies and business models that build competitive advantage through assembling and orchestrating difficult-to-replicate assets, thereby shaping competition itself.

In the context of dynamic capability, the ability to integrate and combine organizations into virtual network partners must be seen as a core skill. The combination of knowledge within the firm and between the firm and external partnering organizations is important. Superior design and the creation of learning, knowledge-sharing, and knowledge-integrating procedures are likely to be critical to business performance. Of equal importance are monitoring and managing the 'leakage', misappropriation and misuse of knowledge, trade secrets, and other intellectual property. Failure to proactively monitor and protect knowledge and intellectual property is prevalent among today's organizations. Dynamic capabilities integrate and synthesize concepts and research findings from the field of ***strategic leadership and management,*** business economics, law, economics, organizational sciences, and research and innovation development projects (Semolič and Steyn, April 2023).

Dynamic capabilities reside in large measure with a firm's ***top leadership team***, but are impacted by the organizational processes, systems, and structures that the enterprise has created to manage its business. Maintaining dynamic capabilities thus requires entrepreneurial ***collaboratist leadership*** and management since it involves recognizing problems and trends, directing (and redirecting) resources, and reshaping organizational forms, structures and systems so that they create and address opportunities while staying in alignment with customer needs.

Important resources of the Industry 4.0 economy are innovation, knowledge and information inspired by ***collaboratist leadership.*** Particularly in manufacturing entities modern innovation is profoundly supported by key technologies and enablers (EFFRA 2017, Steyn and Semolič, May 2024). Moreover, knowledge- and process-based networked organizations, combined with portfolio-, programme- and project management evolved as important Industry 4.0 strategic key success factors. Major sources of

knowledge creation for purposes of knowledge management are Innovative Continuous Improvement Projects resulting from Systems Thinking initiatives emanating from a formal Quality Management System; Research and Innovation Development (RID) Projects; and Organizational Development (OD) initiatives performed through Strategic Transformation and Change Projects (Steyn and Semolič, Nov 2022).

According to Semolič and Steyn (Aug 2018) post-globalisation Industry 4.0 is characterised by digitalized high-technology and instability of business environments, demanding continuous inflow of leadership inspired novelties, innovative improvements, and change. Today's products are created by a mix of interrelated technologies powered by different professions and industries. Digital and innovation literacy, supported by ***collaboratist leadership*** through a culture and mindset of collaboration on all levels and areas of business is becoming the critical enabling competency of societies for finding new authentic business models for exchange of information and ideas. Professor Otto Scharmer of the Massachusetts Institute of Technology (MIT) avers that currently too much outdated Industry 2.0, and 3.0 mindsets still prevail in organizations.

Scharmer argues that current 4.0 problems with 3.0 and worse mindsets cannot solve today's problems. The new millennium has developed into an Industry 4.0 connected-complex-whole-ecosystem, but thinking is way behind stuck in 2.0 and 3.0 based on scarcity, fear, competition, and control. The only way to truly change is to upgrade the awareness of the participants in a system. Scharmer opines that outdated paradigms and beliefs are the biggest threats. Steyn and Semolič (March 2017) opine that modern effective and efficient virtual dynamic learning organizations (VDLOs) have become more cross-functional, flexible, agile, and virtual over time. Their boundaries are blurred and not closed as they were at the time of the early industrial eras. In the Industry 4.0 economy, it is profoundly important to master the management and leadership complexity challenges of operations including the supply chain portfolio.

Steyn and Semolič (2017, March) aver that the Industry 4.0 approach espouses the view that leadership constitutes a collaborative and creative journey with people, defining this as ***"collaboratist leadership".*** They define *"collaboratism"* as a leadership, management, and governance system profoundly important for organizations operating in a virtual network business model to create, produce, and deliver products and/or services to customers in the marketplace. The system is characterised by an initiating organization acting as the principal partner in the virtual network of participating organizations, and founded on project, programme, and portfolio management principles.

Moreover, Steyn and Semolič (2017, March) aver that an important action of ***leadership*** is to define the value system which embeds the organization's values, beliefs, and guiding principles. The guiding principles constitute the total quality management philosophy principles adopted by the organization to aid their operations in all the processes of the value chain. The value system dictates the preferred organizational culture and mindsets adopted through the guidance of the ***executive leaders.*** The leadership process creates potential for high-performance teams by building on the strengths of team members, while the management process entails achieving the organization's strategic goals through efficient planning, organising, workflow, information control and budgeting.

As alluded to above the preferred organizational behaviour and culture are informed by the value system of the organization. Its values, beliefs and guiding principles form the basis for achieving an organization's vision and mission (Steyn, June 2010). Industry 4.0 ***collaboratist leaders*** are guardians of the value system, requiring them to role-model the preferred organizational culture and behaviour. This has the effect of preventing bureaucratic behaviours where employees blame one another and continuously make excuses for failures. Moreover, staff members are transformed to a 4.0 mindset of cooperation, collaboration and team-based success. To be successful the above ***leadership*** aspects are essential for all partner organizations in a virtual network.

Conclusions

Current technologies allow access to global sources of information every step of the way. These come from verified and unverified sources accessible through the open cyber market. Which professional suggestions should be followed, and which should not be followed? The correct decision must be underpinned by arguments based on verified facts from the international knowledge base and experience. Accordingly, this article commenced with the authors' theoretical approach to aspects of Industry 4.0 transformation processes and changes.

Every technology is innovated for the benefit of people and cannot be considered as such without considering their needs, organization of its use, new competencies required, and behavioral changes. Practice shows that Industry 4.0 technologies are still viewed as magic wands, the introduction of which will automatically benefit all stakeholders and indirectly benefit society. However, this is not the case. No improvements can be expected without comprehensively (technologically, organizationally, and behaviorally) pursuing business excellence requirements projects and programs.

As for Industry 5.0, the authors believe critical technologies will appear sooner rather than later, causing the next technological revolution. Great potential and expectations are associated with future generations of artificial intelligence, which will support humans implementing and managing operational processes. However, this stage has not yet been reached.

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About the Authors

Prof Dr Brane Semolič

Founder and Head of LENS Living Lab
International living laboratory
Celje, Slovenia

Brane Semolič studied mechanical engineering, engineering economics, and informatics; he holds a scientific master's degree and doctorate in business informatics. His focus of professional interest is industrial and system engineering, innovation and technology management, virtual organizations and systems, project and knowledge management. He has 40 years of working experiences in different industries (industrial engineering, IT, chemicals, household appliances, government, and education), as an expert, researcher, manager, entrepreneur, counselor to the Slovenian government and professor. He operates as head of the open research and innovation organization LENS Living Lab. LENS Living Lab is an international industry-driven virtual living laboratory. He is acting as initiator and coordinator of various research and innovation collaboration platforms, programs and projects for the needs of different industries (ICT, robotics, laser additive manufacturing, logistics, education). He was co-founder and the first director of the TCS - Toolmakers Cluster of Slovenia (EU automotive industry suppliers). Since 2004 he is serving as the president of the TCS council of experts. Besides this, he is operating as a part-time professor at the Cranefield College.

He was head of project and information systems laboratory at the Faculty of Mechanical Engineering, Head of the Project & Technology Management Institute at the Faculty of Logistics, University of Maribor and professor of project and technology management at the graduate and postgraduate level. He acted as a trainer at the International »European Project Manager« post-graduated program, organized jointly by the University of Bremen.

He was the co-founder and president of the Project Management Association of Slovenia (ZPM), vice president of IPMA (International Project Management Association), chairman of the IPMA Research Management Board (2005-2012), and technical vice-chairman of ICEC (International Cost Engineering Council). He actively participated in the development of the IPMA 4-level project managers' certification program. He introduced and was the first director of the IPMA certification program in Slovenia. He has been serving as the assessor in this certification program since 1997. He performed as assessor in the IPMA International PM Excellence Award Program in China, India, and Slovenia.

Brane is a registered assessor for the accreditation of education programs and education organizations by the EU-Slovenian Quality Assurance Agency for Higher Education. He was a Member of Strategic Advisory Board of European Competitiveness and Innovation, as well as the president of the Slovenian Chamber of Business Services. Brane received the award as ICEC Distinguished International Fellow in 2008. He received the »Silver Sign« for his achievements in research, education, and collaboration with the industry from the University of Maribor in 2015.

Professor Semolič is also an academic advisor for the ***PM World Journal***. He can be contacted at brane.semolic@3-lab.eu. Additional information about the LENS Living Lab can be found at http://www.3-lab.eu/ .

To view other works by Prof Semolic, visit his author showcase in the PM World Library at https://pmworldlibrary.net/authors/brane-semolic/

Prof Dr. Pieter Steyn

Cranefield College
South Africa

Dr. Pieter Steyn is Founder and Principal of Cranefield College, a South African Council on Higher Education / Department of Education accredited and registered Private Higher Education Institution. Cranefield offers an Advanced Certificate, Advanced Diploma, Batchelor of Business Administration degree, Postgraduate Diploma, Master's degree (MCom), and PhD. He holds the degrees BSc (Eng), MBA and Doctor of Commerce, and is a registered Professional Engineer.

He was formerly professor in the Department of Management, University of South Africa and Pretoria University Business School. He founded the Production Management Institute of South Africa, and in 1979 pioneered Project Management as a university subject at the post-graduate level at the University of South Africa. Prof Steyn also taught at the Chung-Shan Institute of Science and Technology in Taiwan as a guest lecturer.

He founded consulting engineering firm Steyn and Van Rensburg (SVR). Projects by SVR include First National Bank Head Office (Bank City), Standard Bank Head Office, Mandela Square Shopping Centre (all in Johannesburg), as also, Game City- and The Wheel

Shopping Centres (in Durban). He, *inter alia,* chaired the Commission of Enquiry into the Swaziland Civil Service; and acted as Programme Manager for the Strategic Transformation of the Gauteng Government's Welfare Department and Corporate Core.

Prof Steyn is a contributing author of the "*International Handbook of Production and Operations Management*," (Cassell, London, 1989, ed. Ray Wild) and is the author of many articles and papers on leadership and management. He is a member of the Association of Business Leadership, Industrial Engineering Institute, Engineering Association of South Africa, and Project Management South Africa (PMSA); and a former member of the Research Management Board of IPMA. He serves on the Editorial Board of the PM World Journal. Moreover, he is the owner of the Aan't Vette Wine Estate and De Doornkraal Vinotel (4-star hotel) in Riversdale, Western Cape.

Prof Steyn can be contacted at cranefield1@cranefield.ac.za. For information about Cranefield College, visit www.cranefield.ac.za.

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