


Sustainable Development In Industry 4.0 and the «Virtual Corporation»: Similarities and Differences

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Abstract: Examining the effects of the technological components of Industry 4.0 on the structure of companies, one is reminded of an organizational concept that was popular at the turn of the Millennium: the Virtual Corporation (VC). As early as 1993, the American authors William Davidoff and Michael Malone proclaimed the "virtual revolution". For them, the decisive building block for the formation of a new economic system was the Virtual Corporation. The literature attributed to this concept the ability to solve the problems of large companies (such as inflexibility) and small enterprises (such as poor economies of scale) simultaneously and to combine the best features of both extremes of company size. This article discusses, which prerequisites for the implementation of VC, then mostly dreams of the future, are given today and how the concept of the VC can complement Industry 4.0 for sustainable development of organizations and serve as a role model on an organizational level.


1 INTRODUCTION


The literature on Industry 4.0 mainly deals with the technological perspective and discusses trends in modern technologies such as the Internet of Things, Edge vs. Cloud Computing, Artificial Intelligence, Augmented Reality, Additive Manufacturing, Collaborative Robots, the Administrative Shell or the Digital Twin. Looking at the effects of these technological components on the organizational structure of companies, one is reminded of a now lost organizational concept that was popular at the turn of the millennium: the Virtual Corporation.

As early as 1992, the American authors William Davidoff and Michael Malone proclaimed the "virtual revolution". For them, the decisive building block for the formation of a new economic system was the Virtual Corporation. They attributed to this concept the ability to simultaneously solve the problems of large companies (such as inflexibility) and small enterprises (such as lack of economies of scale), thus combining the best features of both concepts (Schröder 1996). However, disillusionment began to

emerge in theory and practice at the end of the 1990s: Above all, the inadequate conceptualization and the lack of technological prerequisites entailed that the success stories from practice remained isolated cases and the concept slowly faded into the background. The last publications regarding the Virtual Corporation date from around 2006, and theoretical research on organizational theory shifted to other topics. Practice pounced on the new paradigm of Industry 4.0. But in recent years, the organizational structure and process organization of companies in Industry 4.0 have moved significantly towards the Virtual Corporation - curiously, without mentioning this term. What are the reasons for this?

This article will work out that the technological prerequisites for the formation of Virtual Corporations are not only given today, but that the ever-increasing challenges for companies force a virtualization of the organizational structure. And that, conversely, a more effective conceptualization of the Virtual Corporation (VC) becomes possible through the orientation towards practice. In order to classify this organizational model, the second chapter briefly

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introduces the concept of the Virtual Corporation with its strengths and weaknesses and discusses the reasons for its failure. In the next step, the article highlights the challenges posed by the Fourth Industrial Revolution and introduces the concept of Industry 4.0. Afterwards, the similarities and differences to the concept of the VC are worked out. The article concludes that Industry 4.0 unconsciously uses many of the characteristics of the Virtual Corporation. It further explains that a more consistent alignment of the organizational structure with the concept of the VC can lead to significant competitive advantages. For this reason, the article dares to predict that a renaissance of this concept is imminent.

2 METHODOLOGY

Document analysis was used as the main research method. The objects were scientific publications (articles in journals and conference collections) not only in English, but also in German and Russian. Based on comparative analysis and comparisons, the article identifies the differences and similarities between the concept of Industry 4.0 and the Virtual Corporation.

3 THEORETICAL FRAMEWORK

The concept of the Virtual Corporation (VC) began with two groundbreaking publications in the early nineties. Davidow and Malone set themselves apart in 1992 in their bestseller “The Virtual Corporation: Structuring and Revitalizing the Corporation for the 21st Century”, in which they dealt with virtual products and their manufacturers. They enriched their argumentation with popular management trends and thus arrived to the VC as the concept of the future (Davidow and Malone 1992). A cover story in 1993 in the Business Week by Byrne, Brandt and Port shaped the prevailing view of the VC as a temporary coupling of highly specialized units. They based their argumentation on an arbitrary collection of success stories of already “virtualized” companies in order to “prove” the attractiveness of their concept (Byrne, Brandt and Port 1993). In many cases, the VC was even seen as the decisive building block for the emergence of a new economic system (Bleecker, 1994) and was able to take the lead in modern organizational models for a while (Weibler and Deeg 1998).

In the absence of a definition by Davidow and Malone, the definition by Byrne, Brandt and Port as co-authors of the concept is presented:

“The virtual corporation is a temporary network of independent companies, suppliers, customers, even erstwhile rivals linked by information technology to share skills, costs and access to another one's markets. It will neither have central office nor organizational chart. It will have no hierarchy, no vertical integration (...) In the concept's purest form, each company that links up with others to create a virtual corporation will be stripped to its essence. It will contribute only what it regards as its core competencies.” (Byrne, Brandt and Port 1993)

This revolution is already underway and is providing new answers, leading to the Industry 4.0 paradigm. The term “Industry 4.0” originated in 2011 from a project of the German government's high-tech strategy that promoted the computerization of manufacturing (Ohno 1988) and was presented to the public at the Hanover Fair in the same year (Hopp and Spearman 2008). In October 2012, the German government's Industry 4.0 working group presented a series of implementation recommendations. The members and partners of this working group are recognized as the founding fathers and driving force behind Industry 4.0 (Dombrowski and Mielke 2014), which can be simply defined as the sum of all technological and organizational approaches to meet the challenges of the Fourth Industrial Revolution.

Some authors from Russia have also devoted their works to this topic recently (Hering, S., & Fayzullin, R. (2020), Zolkin, A. L., Faizullin, R. V., & Dragulenko, (2020), V. V. Zuev A.S., Makushchenko M.A., Ivanov M.E., Merkulov E.S. (2020)). However, in the modern world, it is necessary to understand that there is no single concept that could be tied to a single country, for example Germany (one of the leaders of Industry 4.0), Russia or another country. Modern technologies require consolidation, globalization and information exchange. «The evolution of global networking concepts is reflected in the theories of global manufacturing networks focused on the local and global dimensions of institutionalization, corporatization, and technologicalization and digitization» (Dzwigol, H., Dzwigol-Barosz, M., & Kwilinski, A. (2020)).

It is important to study the Industry 4.0 because of the need for sustainable development of economic systems. «The newest revolution in the era is termed as Industry 4.0, controls the entire life cycle of the product and has the potential to produce innovative solutions for global issues faced in sustainable development» (Sangwan (2020)). «The virtual

corporation can offer sustainable comparative advantages for small and medium-sized enterprises» (Rautenstrauch (2002)).

4 SIMILARITIES AND DIFFERENCES BETWEEN INDUSTRY 4.0 AND THE VC

The basic idea of Industry 4.0 is based on two thoughts: the global networking of people, plants and products as well as the independent and decentralized self-organization and control of these production units in real time. These two elements – the dynamic networking of partners and the principle of self-organization – are also at the heart of the concept of the Virtual Corporation. This striking similarity suggests the conclusion that there are many more similarities. This chapter therefore examines the similarities and differences between Industry 4.0 and the VC concept.

4.1 Similarities

Another fundamental common feature is that both concepts have an intra- and an inter-organizational perspective. After all, Industry 4.0 can also be treated from two poles: The intra-organizational perspective looks at individual companies that optimize their part of the value chain internally. From an inter-organizational perspective, several companies – suppliers, producers, customers – are interlinked by Industry 4.0 along the entire value chain. Furthermore, there are other commonalities, which are presented in the following.

4.1.1 The Role of Globalization

Globalization represents both a threat and an opportunity for VCs: On the one hand, the ongoing deregulation of markets is leading to an increase in the number of rival suppliers from other countries and resulting in significantly increased competitive pressure. On the other hand, a company can withstand this pressure by making optimum use of the world's best resources to provide its services. Globalization also opens up opportunities for expansion into previously closed markets. Not only do manufacturers offer their products worldwide, but they also use global sourcing to obtain the necessary resources regardless of their geographical location (Picot, Reichwald and Wigand 1998). Globalization was seen as a driver for the formation of VCs: Global

competition blurs the identity of producers of goods and services (Goldman, Nagel, Preiss and Warnecke 1996). The unlimited opportunities for cooperation with companies all over the world made the formation of VCs possible. Global alliances of legally independent organizations became a reality.

Globalization is also one of the germ cells of Industry 4.0, which, through the global division of labor, covers not only production but all parts of the value chain. Wildemann states: The intensification of globalization also entails the market entry of competitors from outside the original industry (Wildemann 2018). The requirements in terms of product quality, delivery capability, availability, deadline flexibility and price elasticity are increasing massively. He predicts: Because of globalization, too, companies will no longer be able to precisely map all processes at all times. They will find themselves in a complex field that can no longer be described or predicted. Companies would therefore have to become more versatile, flexible and agile in order to be able to adapt to changes quickly and economically. They can only meet these challenges if they completely change the way they create value. This sounds not only like a plea for Industry 4.0, but also for the formation of VCs.

4.1.2 Central Importance of ICT

As early as the 1990s, when the concept of the VC was booming, it was found that technical progress had accelerated more and more since industrialization. It was difficult for an individual company to keep up with this pace, because the extent and speed of technological change had increased dramatically (Hahn 1988). The main focus of this development was the rapid development of ICT (Hahn 1988), which was causing the most serious upheavals due to its universal applicability in practically all functional areas of companies.

The Internet as a "global infrastructure for the exchange of information and data" (Picot, Reichwald and Wigand 1998) played an important role in this context. From a technological point of view, it energetically drives the globalization of the procurement and sales markets and enables the use of the world's best input factors as well as sales on a global scale. Full-bodies promises were made that the vision of the "global village" would thus become reality for many companies, because geographically distant companies would move closer together in the process of creating services in order to form powerful Virtual Corporations. But at that time, the reality of ICT and the Internet was still far removed from these

bold ideas. The possibilities of the Internet in particular were still limited at that time.

ICT and the Internet are just as crucial to the success of Industry 4.0: Instead of steam engines or assembly lines, this time ICT will be the key. This is where a large part of the necessary innovations will come from (Bauernhansl, ten Hompel and Vogel-Heuser 2014). Although ICT puts companies under great pressure to innovate, it also opens up completely new possibilities for organizational design. According to Wildemann (Wildemann 2018), performance improvement and cost reduction in ICT are therefore an essential basis of Industry 4.0, because they make digitization possible in the first place.

The merging of real and virtual worlds creates a Smart Factory: the vision of a dynamic, real-time optimized and independent production, which is constantly reconfigured by self-organization. And that sounds a lot like a Virtual Corporation.

4.1.3 Decisive Role of Networks

Another similarity lies in the central importance of the network idea for both Industry 4.0 and Virtual Corporations. With great agreement, network structures are proclaimed in the literature as a constituent element of VCs (Krystek, Redel and Repegather 1998). Reminder: VCs are cooperations in dynamic networks. This is where a problem-related linking of real resources takes place to cope with specific tasks (Picot, Reichwald and Wigand 1998). VCs are particularly useful when external core competencies are to be harnessed. The entire value chain can be optimized by restricting the company to its own core competencies and combining them with complementary core competencies from other companies.

The network idea also forms the core of Industry 4.0., although it is much more technological and concrete here: decentralized, autonomous units communicate with each other omnipresently via the Internet of Things, and thus form a CPS: smart products, intelligent work pieces, machines, transport units and other units work together in an automated and synchronized manner and interact with humans via interfaces to form an industrial network (Wildemann 2018). Using real-time data, the network permanently updates the virtual image of reality. This enables the real world to merge with the virtual world (Bauernhansl, ten Hompel and Vogel-Heuser 2014). Virtualization therefore plays a decisive role in both concepts.

In addition, the potential of Industry 4.0 is only fully exploited if the sphere of action covers the entire value chain: from development, production, logistics to sales & after sales (Wildemann 2018). In this respect it is similar to an inter-organizational VC, which ideally also covers the entire value chain.

4.1.4 Self-organization as the Overriding Principle

The role of the networks has already alluded to the importance of self-organization for the VC and Industry 4.0. For a VC, it is the most important principle next to process orientation, which is expressed in attributes such as "independent", "self-optimizing" or "autonomous", which are used almost inflationarily in the relevant literature.

The emphasis on the importance of self-organization culminates in the statement that the survivability of a VC is only given if self-organization largely replaces the external organization by granting the system members greater autonomy. Of great importance for self-organization is the rapid availability of information across subsystems (Krystek, Redel and Repegather 1998). Self-organization increases flexibility considerably, promotes the dissolution of rigid structures and horizontal and vertical boundaries and thus creates a VC. Self-organization also plays a central role in Industry 4.0. Wildemann explains that it enables decentralized, self-sufficient and self-optimizing production processes and supports companies in avoiding waste and reactive power, thus achieving increased resource efficiency (Wildemann 2018).

A CPS builds up networks autonomously and decentrally in order to optimize itself independently. The individual elements communicate with each other via the Internet of Things and network themselves independently. Many machines and systems are self-optimizing. This is made possible by intelligent objects that communicate with each other via standardized interfaces: These include smart products, smart tools and smart machines that can be easily combined with each other according to the "Plug & Produce" principle. Self-organization even goes so far that the machines independently inform about their maintenance status in the sense of "predictive maintenance" or initiate necessary maintenance work themselves in order to minimize waiting times and repair failures. All this was not yet conceivable when the concept of the VC was devised. Nevertheless, the intelligent objects apply the same principles of self-organization as a VC.

4.1.5 Consistent Process Orientation

A VU is also referred to as an „as-if“ organization (Berkley and Nohria 1991), as it has the possibilities and potential of a traditional organization without being tied to a comparable institutional framework (Klein 1994). Without the permanent implementation of central functions or hierarchical structures (Wicher 1996), a dominance of the process over the organizational structure is achieved (Schröder 1996), which serves an efficient process orientation. If external companies are involved in the creation of core processes, it becomes increasingly unclear where one company ends and the other begins as the level of interlocking increases (Picot, Reichwald and Wigand 1998). This approach thus leads not only to the flexibilization of capacity limits, but also to the dissolution of boundaries between companies. Without its own legal form, company headquarter and employees (Byrne, Brandt and Port 1993), a VC can adapt better to market dynamics and changing customer needs (Wuethrich and Philipp 1998).

With Industry 4.0, companies retain their legal form, headquarters and identity. However, these companies still rely on the same principles of process orientation. Online process controls continuously monitor the value-added process so that, for example, deviations are detected and automatically corrected within the ongoing production process to reduce waste. By networking all value creation processes in real time, the original conflict of goals between efficiency and flexibility is eliminated. Increased flexibility in manufacturing, digitization and automation enable significant savings. In this way, great value creation potential can be realized with a low input of resources. This even enables flexible and efficient production in batch size 1 (Wildemann 2018). Even if the VC could not keep this promise at the time: The resolution of the trade-off between efficiency and flexibility also characterizes concept of the VC.

And there is another parallel: Industry 4.0 affects almost all areas of a company. Since the core processes of the individual divisions are closely interlinked, implementing the design principles of dynamic allocation and self-organization brings about fundamental changes in the overall organization: Cross-divisional thinking also leads to the fact that the indirect divisions, i.e. the supporting functions, can be reduced or even eliminated (Wildemann 2018) – just as with the VC.

4.2 Differences

The fundamental difference between the two concepts is that Industry 4.0 follows a technological approach and the VC follows an organizational theory approach. For example, the companies in Industry 4.0 do not use a consistent organizational model, while conversely, the observations on the VC as a whole were significantly less technological. The differences are most obvious, however, in the role that humans play in both concepts.

4.2.1 The Role of the Human Being

At first glance, both concepts take the same approach: At a VC, people are placed at the center of events through a high degree of autonomy and the many opportunities for participation through team structures. In this way, a VC ensures that its employees identify with it (Krystek, Redel and Repegather 1998). Their motivation is strengthened by the distribution of decision-making powers (Goldman, Nagel, Preiss and Warnecke 1996).

However, VCs also emphasize the extraordinarily high demands on employees. In addition to profound expertise, employees must be able to lead and motivate themselves to a large extent, have good communication and social skills and master the new technologies (Drumm 1996). As explained for the intra-organizational weaknesses of VCs, some authors express doubts as to whether the extreme speed of adjustment required of employees is realistic. Ultimately, people were perceived as a limiting factor in a VC.

In Industry 4.0, on the other hand, intelligent technology such as smart products takes a large part of the coordination burden off the shoulders of people in the complex manufacturing process. In contrast to the VC, Industry 4.0 provides concrete answers to this challenge: For example, robots have been developed for automobile production that are smaller, more flexible and better adapted to working with humans in order to combine mechanical and human strengths. Humans are connected to the CPS via multimodal interfaces and can control it, for example, by voice, touch displays or gestures (Wildemann 2018). Through innovative man-machine cooperation, such as Cobotics, and the observance of the principles of ergonomics in the workplace, it is even possible to integrate older and more experienced employees as active factors in the production process. Correctly applied, Industry 4.0 fully exploits human and technological potential and combines it in an ideal way.

Further problems for VCs arise from the lack of employee loyalty: on the one hand, employee loyalty is essential for the success of the company (Wicher 1996), but on the other hand, the high fluctuation of the employees leads to a kind of "mercenary mentality" (Mertens, Griese and Ehrenberg 1998). This area of conflict is almost impossible to resolve. Most companies in Industry 4.0 do not have this dilemma because they offer their employees long-term and stable structures.

4.2.2 The Role of Globalization

Both concepts emphasize the importance of globalization as a driver of constant change. The only difference is that globalization has advanced significantly since the 1990s. As a result, the challenges posed by globalization have increased.

4.2.3 Central Importance of ICT

ICT plays a central role as an enabler in both concepts, and naturally even more so in the more technologically oriented approach of Industry 4.0. While ICT was still a limiting factor for VCs at the turn of the millennium – for example, the Internet was not yet available globally at sufficient speed – modern ICT is able to meet the requirements of both Industry 4.0 and the VC. The decisive difference to that time is: technology serves people, but does not overwhelm or control them.

4.2.4 Decisive Role of Networks

Both the VC and Industry 4.0 emphasize the importance of flexible linking of autonomous units. The network idea forms the core of both concepts. However, while the limited lifetime is a constitutive feature of VCs, the technologies of Industry 4.0 are mainly applied in stable networks, such as within existing company boundaries, which are geared toward the long term.

Furthermore, the nodes of the network in Industry 4.0 are mainly technological components such as smart products, work pieces or machines, whereas in VCs these are legally independent units. However, since Industry 4.0 companies can also link up with suppliers, producers and customers along the entire value chain – which also leads to partnerships with a limited lifespan – It can be argued that Industry 4.0 companies can also be VCs.

4.2.5 Self-organization as the Overriding Principle

This element also makes it clear: Despite all the focus on self-organization in the specific process of production, an Industry 4.0 company still has a headquarter where the strategic direction and long-term goals of the company are formulated, coordinated and where the fulfillment of goals is monitored. In contrast, the pure form of a VC proclaims a complete renunciation of the institutionalization of central functions and the extension of self-organization to all areas.

As mentioned, however, it is doubtful whether the coordination and allocation of resources is really more efficient through self-organization alone than through targeted, central control. A pure self-organization is overstrained with this complexity. In this respect, it is questionable how viable a VC would be in its pure form, whereas companies in Industry 4.0 prove their efficiency every day in practice. Despite all this self-organization, central control is essential for survival.

4.2.6 Consistent Process Orientation

The central importance of process orientation is common to both concepts. The main difference here is that processes at VU are viewed primarily from the perspective of organizational theory – for example, in the dominance of the process over the organizational structure – while Industry 4.0 focuses on very specific technological components.

5 RESULTS AND OUTLOOK

The bottom line of the article shows that the similarities of the two concepts outweigh the differences. This is most obvious in the role of technology: much of what had to remain theory at the turn of the millennium is now reality. In particular, the virtualization of the world in real time has advanced very far through modern technological concepts such as the digital twin or the administrative shell. Because the performance required at the time of the origin of the VC is now available, ICT, which breathes life into Industry 4.0, can also give new impetus to the organizational theory concept of the VC.

A renaissance of the VC could be imminent because Industry 4.0 solves many of the practical problems that were unsolvable for VCs in their "founding days". Another key reason is the fact that

the challenges for companies back then were not as extreme as today. In the 1990s it was proclaimed that challenges threatening the existence of the company would force a "virtual revolution" and the formation of VCs. This revolution did not take place then because the pressure was not yet great enough.

If one compares the global environment and competitive environment of companies from twenty years ago with today, one can see that complexity and dynamics have literally exploded. Until well into the 1990s, companies were still stuck in the mechanisms and concepts of Industry 3.0. But the Fourth Industrial Revolution is changing everything in society, politics and the economy. The best example is digitization, the radicality of which could not be imagined at the time and which only really took off with the triumphant advance of the iPhone. Among other things, digitization is leading to the disruption of entire industries and the creation of completely new business models such as "pay per use", culminating in the concept of "XaaS" (Everything as a Service).

6 CONCLUSIONS

In summary, it can be stated that the challenges now exist which should have forced the formation of VCs at the time and that at the same time, with the approaches of Industry 4.0, concrete instruments and technologies are available for implementation. So if VCs are currently being forced and enabled at the same time, it is surprising that the world does not appear to be full of VCs.

First of all, there is a simple reason for this: the concept of the VC is primarily concerned with organizational structures, it is a revolutionary organizational model for sustainable development of organizations. Conversely, the Industry 4.0 concept focuses primarily on revolutionary technologies, so the approach is technology-driven and much more rooted in practice. The originators of Industry 4.0 have perhaps not yet given enough attention to the exclusively organization-theoretical implications of their model – for if they had, they would already have realized that this would bring them very close to the concept of the VC. This is also due to the definitional and conceptual imprecision identified in the article. Furthermore, if one doesn't know what a VC really looks like, how should one set up one?

An important task for the future is therefore to further develop the concept of VC and above all to adapt it to today's conditions. After all, the more important value creation through new digital business

models becomes, the more cross-company collaborations are becoming part of daily practice and the more questions such as the protection of intellectual property are arising, the more one will have to deal with the question of how companies or groups of companies are actually set up in process and organizational structure, in theory and practice. And the more virtualization penetrates into everyday business life, the more the concept of the VC offers itself as an aid. If theory paves the way, there is a high chance that the concept of the Virtual Corporation will be revived – just as its founding fathers Davidow, Malone, Byrne, Brandt and Port once dreamed of.

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