The organizational concept of the virtual corporation and its integration into Industry 4.0

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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 and serve as a role model on an organizational level.

Keywords: INDUSTRY 4.0; VIRTUAL CORPORATION; ORGANIZATION THEORY; INDUSTRIAL REVOLUTION; INFORMATION COMMUNICATION TECHNOLOGY; TECHNOLOGICAL ADVANCEMENTS

1. Introduction

The literature on Industry 4.0 mainly deals with the technological perspective and discusses trends in modern technologies such as Artificial Intelligence, the Administrative Shell or the Digital Twin. Analyzing the effects of these technological components on the organizational structure of companies, one is reminded of the organizational concept of the Virtual Corporation.

The goal of this article is to show how the two concepts Industry 4.0 and the Virtual Corporation (VC) complement each other and how the VC can serve on an organizational level to make companies more successful. Chapter two briefly describes the current status of Industry 4.0. The third chapter introduces the concept of the Virtual Corporation. Chapter 4 examines the similarities and differences between the concepts of Industry 4.0 and the Virtual Corporation, how the integration of the VC concept into Industry 4.0 could look like and why this is so important.

2. A Brief Analysis of Industry 4.0

The 4th Industrial Revolution is about to revolutionize the entire value chain of almost all branches of industry and to initiate a paradigm shift. Industry 4.0 bundles the answers to those challenges. This chapter briefly introduces the three most important principles of action of Industry 4.0: Digitization, automation and new business models as well as some key technologies.

2.1 Principles of Action of Industry 4.0

Companies are facing increasing external and internal complexity and dynamics. In many industries, the dominant technologies are being replaced. Disruptions occur because new business models turn everything upside down. Digitization is primarily responsible for this: It is changing our lives more than any other megatrend. People are constantly online - and companies have to follow them into these virtual spaces, forcing them to undergo a structural change, the digital transformation [1].

Information and communication technology (ICT) paved the way for Industry 4.0, and Cyber-Physical Systems (CPS) is its manifestation, because its paradigm is based on the fusion of the physical world with the virtual world into CPS [1]. These consist of buildings, production facilities, logistics components, equipment, means of transport and other objects. All these elements are uniquely identifiable, record their environment with sensors, evaluate the information thus obtained with the help of globally available data and services, save it and act in the physical world with the help of actuators such as robots. The individual elements communicate with each other via the Internet of Things (IoT). An advanced CPS can build autonomous and decentralized networks and optimize itself independently. Three interdependent principles of action are vital for Industry 4.0.

2.1.1 Digitization

Digitization is bringing the IoT into factories and leads to the creation of CPS. Digitization links material flows with data. This makes it possible to network resources, machines and logistics systems online. This enables decentralized, self-sufficient and self-optimizing production processes and supports companies in avoiding waste and reactive power, thus contributing to increased resource efficiency. Today, complete horizontal and vertical integration can link the entire supply and value chain and improve collaboration, coordination and transparency in global corporate networks. This fundamentally changes the relationship between suppliers and manufacturers [2].

2.1.2 Automation

In the past, there was a trade-off between automation and flexibility: the more automated the production, the less flexible it was. Progress in ICT is resolving this conflict of goals. Automation replaces mechanical work with software-controlled processes. Online algorithms continuously control and monitor the value-added process so that, for example, deviations can be detected and the production process can be automatically switched off to reduce scrap. Smart products play an important role here: They know their properties and know how they are to be manufactured, in which phase of the manufacturing process they are, and where they should be delivered next. They also know which machines or systems they can be connected to [2]. Automation can increase decentralization, scalability, transparency and flexibility along the entire value chain.

2.1.3 New Business Models

Man is empowered by technology: He becomes the conductor of the value chain and generates new business models. Other drivers are the changed and expanded processes. Formerly known value chains are developing strongly. All this not only changes existing business models, but also leads to the emergence of new ones. The focus is on a fundamental rethink: it is no longer products that are sold, but customer benefits. Examples of the digital finishing of products are, for example, ‘pay-per-use’ models: the customer no longer pays for a particular machine tool but for the number of pieces produced on that machine (‘pay-per-piece’) [1].

2.1.3 Key Technologies

As mentioned, the development of Industry 4.0 is technology-driven and is made possible by ICT. Figure 1 gives an overview of the most important technologies:
Fig. 1: Key Technologies for Industry 4.0 (Source: Own Illustration)

Current trends in ICT such as data mining, cloud services and technological advances in sensor technology form the basis for the expansion of CPS. Those ultimately lead to Smart Factories. And a wealth of Smart Factories is creating a completely new industrial landscape: Industry 4.0 [2].

3. Introduction of the Virtual Corporation (VC)

Ever since the science fiction author William Gibson coined the term "cyberspace" in 1982, the attribute “virtual” has become very popular. It specifies phenomena that are not physically present, but whose full performance is nevertheless available. In the 90s, the attribute “virtual” seemed to provide a guarantee for the future in an ever faster changing world. In the economic literature, Scholz even proclaimed an evolution of the concepts of virtuality, ranging from “virtual memory” to “virtual product” to the Virtual Corporation (VC) as the preliminary end point of a logical development [3].

The concept of the VC began with two groundbreaking publications in the early nineties: The 1992 bestseller of Davidow and Malone dealt with virtual products and their manufacturers. The authors enriched their argumentation with popular management trends and thus arrived to the VC as the concept of the future [4]. 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 [5]. 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.” [5]

To date, no universally valid definition of the VC has been established. Since the concept developed rapidly, the definitions always lagged behind the discourse. In order to narrow down the phenomenon of the VC more precisely, the next step is to look at the concept from an intra- and interorganizational perspective.

3.1 Conception

In the literature, the concept is discussed from two perspectives: From an intra-organizational perspective, it is shown how a single company is structured internally to become a VC. The company changes from a hierarchical to a hybrid form of organization in which the company units are equipped with a higher degree of autonomy and cooperate on a project-related basis. From an inter-organizational point of view, a large number of legally independent companies merge to form a VC. Coming from the two opposing poles of market and hierarchy, a hybrid form of organization is thus realized from both perspectives.

3.1.1 Conception from an Intra-Organizational Perspective

Traditional business administration according to Scientific Management interprets companies as entities with rigid structures, which are characterized by clear horizontal and vertical boundaries separating departments and hierarchical levels. According to this approach, the essential two elements of a company are its dominating structural and a process organization [6]. In the "evolutionary paradigm", however, companies are understood as complex and networked social systems. Their ability to survive is only given if self-organization replaces the external organization to a large extent by granting the system members more autonomy [7]. Self-organization is a central feature of VCs, along with consistent process orientation.

VCs take this into account primarily by using team-based forms of organization. Strict process orientation is made possible in an efficient way by these ad hoc organizational structures, which are project-related and therefore flexible in their formation and dissolution [8]. In this context, VCs are to be understood as a dynamic team system that spreads almost throughout the entire company [7]. This enables a very high flexibility and adaptability to constantly changing task constellations.

Too much vertical integration ties up too many resources, which are no longer available for the strategically important core tasks and also hinder the flexibility of a company [6]. Vertical integration and complexity are therefore reduced by outsourcing, supplier partnerships or other forms of cooperation. By delegating all other tasks, a VC can focus on its core competencies and optimize its own value chain [9].

"Teleworking" and "mobile computing" are dissolving the boundaries of the company even further. Through its focus on communication and cooperation, telework supports the self-organization of a VC in a significant way and also largely removes the barriers of space and time [10]. This is particularly evident in “mobile computing". Moving away from classic employment relationships further increases the company's flexibility [8].

3.1.2 Conception from an Inter-Organizational Perspective

In classic business administration, the view is held that companies have external boundaries that are clearly defined and sharp. These boundaries are mostly defined by ownership and control rights, uniform management, business areas, common standards, objectives and values or regional structures [11]. Modern organizational theory contradicts this view. Richardson, for example, takes the view that market and hierarchy are only the two poles of a continuum of possible forms of transaction and cooperation [12]. In all types of cooperation, the boundaries between companies become blurred due to the interlinking with the cooperation partners [11].

VCs are based on dynamic networks that can be configured and dissolved quickly and flexibly according to the requirements. This promises high flexibility as well as high efficiency. Legally independent organizational units form the nodes of the network of an inter-organizational VC. When merging to form a VC, each company contributes its core competencies, which are ideally complemented by the core competencies of the other organizational units involved [13]. Since it is assumed that each participant offers the component in which he or she holds the absolute top position, this creates a "best-of-everything-organization" [13] in which all parts of the value chain are optimized.

At the network level, the principle of self-organization ensures the behavioral variety that is necessary to solve complex problems in a dynamic environment [7]. Due to the increasing networking
with market partners and the inclusion of customers in the network, the boundaries between the units involved are becoming increasingly blurred. VCs are to be understood as one-off mergers of organizational units that collaborate on a project-by-project basis to produce a specific product or service - for as long as the market allows [14].

Within these networks, the use of team-based forms of organization in and between companies helps to optimize the entire value chain. Analogous to the dissolution of departmental and hierarchical boundaries in internal team structures, cross-company teams blur the boundaries between organizational units [7]. In spite of the extreme spatial and temporal distribution of the actors and the processes, a VC appears to be a single company for customers and cooperation partners.

Information and communication technology (ICT) plays a particularly important role in this context. It ensures the efficient distribution and coordination of tasks within the company network. The virtual integration of resources through ICT means that neither additional facilities need to be built nor additional staff need to be hired. The already existing, distributed resources remain physically in their place, but are connected to each other electronically [14].

3.2 Strengths of Virtual Corporations

The four classic dimensions of profitability – cost, quality, time and flexibility – provide information on the competitiveness of a company and, accordingly, on the strengths and weaknesses of VCs.

3.2.1 Strengths from an Intra-Organizational Perspective

From a cost perspective, an intra-organizational (i.e. internal) VC is attractive: by limiting the company to its core competencies, all resources are concentrated on the skills that the company can master best and most efficiently. Teleworking saves space and ancillary wage costs when teleworkers are self-employed and/or only add to the core workforce when necessary [7].

The restriction to the most well-managed value creation processes also leads to quality improvements. Team-based forms of organization motivate employees and make optimum use of their learning and performance potential. Mobile computing in particular improves market proximity and customer service significantly [7].

Time can be gained by focusing on core competencies. This enables a lower vertical integration and a shorter lead time. Teams that are configured to meet specific needs solve their tasks faster.

The flexible allocation of resources to constantly changing projects increases adaptability, which is further enhanced by ICT [7]. Telework can attract employees who live far away from the company headquarters. Finally, additional flexibility is achieved by using external capacities for peak balancing [7].

3.2.2 Strengths from an Inter-Organizational Perspective

The combination of the core competences of individual companies opens up the joint synergy potential of all the parties involved. Thanks to ICT, the transaction costs for handling the exchange of services are lower [6]. A minimized administrative apparatus saves fixed costs. Finally, the dissolution of the VC after the end of the project is carried out with little administrative and financial effort.

The qualitatively best components are combined, since each participant contributes the component in which it holds the absolute top position [15]. A VU can offer customer-specific and high-quality goods, which makes it highly attractive for customers. 

Time savings result from the fact that not every partner has to deal with the whole issue from the product idea to distribution [15], since each unit concentrates on the sub-process it controls best. The use of simultaneous processes increases the speed of the process. Due to the extraordinary speed with which a VC can be formed, the speed of adaptation reaches new dimensions [16].

Virtual Corporations are highly flexible due to the wide range of possible combinations of core competencies. The participants can use the size of the network without having to give up their own flexibility and manageability [16]. In this way, economies of scale and experience curve effects can be achieved without having to accept the inflexibility of a large company. The individual companies thus remain relatively small, but together reach a considerable virtual size [17].

3.3 Integration of both Perspectives and Conclusion

If one compares the elements of the intra- and inter-organizational perspective, one finds that there are basic similarities. From an abstract point of view, the same principles apply, only the specific form is different: Team-based forms of organization and cross-company teams differ only in whether one considers a single company or a corporate network. A VC limits itself internally to its core competencies in order to become part of a “best-of-everything” organization in an external network, i.e. an inter-organizational VC. After all, ICT is the key technology in both cases, enabling teleworking and mobile computing, which in turn form a basis for team-based work in both perspectives.

Both perspectives attach great importance to the principle of self-organization and apply the same design principle: the “dynamic and flexible assignment of abstract service requirements to service providers and the specific location of service provision” [18]. The fact that the concrete design is different can be attributed to the opposing starting positions.

Although being a very promising concept, the proliferation of VCs suffered for a number of reasons: The VC was viewed from a wide variety of angles, which painted a very heterogeneous picture. In theory, the ideas about the content and nature of VCs differed widely and, moreover, were often imprecise [10]. The concept therefore initially failed due to its theoretical shortcomings and thus turned out to be rather unsuitable for practice. Two further reasons were that the technological prerequisites for the successful formation of VCs were not yet in place at the end of the last century. And that the proclaimed challenges for companies, which were supposed to force the formation of VU, were not as pronounced then as they are today. As a result of this, the concept was not able to assert itself on a broad front and vanished slowly – until Industry 4.0 provided the conditions for a new proliferation.

4. Integration of Industry 4.0 and the VC into an Overall Concept

This chapter discusses possibilities to develop organizational aspects of Industry 4.0 through the approaches of VCs. First, the similarities and differences are discussed, as well as suggestions to strengthen Industry 4.0 companies through approaches of the VC concept. The next section introduces challenges that need to be overcome so that a further common development can take place. Finally, it is discussed how the integration of both concepts can lead to an overall concept.

4.1 Similarities and Differences

The basic idea of Industry 4.0 is grounded 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 that there might be more commonalities. This chapter therefore examines the similarities and differences between Industry 4.0 and the VC concept.

One 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.

The fundamental difference between the two concepts is that Industry 4.0 follows a technological approach and the VC follows an organizational theory approach. Further differences and commonalities 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 deregulation of markets increases the number of rivals from other countries. On the other hand, a company can make optimum use of the world’s best resources to provide its services and expand into previously closed markets.

Globalization is also one of the germ cells of Industry 4.0, which covers all parts of the value chain. Due to the growing complexity of production and supply chains in connection with increasing customer requirements and the strong dynamics in the markets, companies must become more flexible and agile in order to adapt to changes. They can only meet those challenges if they completely change the way they create value. The VC concept can support Industry 4.0 significantly on an organizational level.

4.1.2 Central Importance of ICT and the Internet

Only ICT and the Internet can tackle the challenges described above. Because of its universal applicability in all functional areas of companies as well as its networking with suppliers, customers and other companies, it is not only the decisive driver of Industry 4.0, but the prerequisite for successful, ICT-driven networking with other companies, as envisaged by the VC concept.

The Internet as a global infrastructure for the exchange of information and data enables the use of the world's best input factors as well as sales on a global scale. One vision of the concept of the VC was the to pave the way to the “global village”. It has become a reality for many companies in Industry 4.0 as geographically distant companies moved closer together to form powerful networks along the value chain. ICT and the Internet are just as decisive for the success of Industry 4.0 as they are for VCs. Streamlining organizational structures according to the principles of VCs with the help of ICT and the Internet can create better results in Industry 4.0.

4.1.3 Decisive Role of Networks

Another similarity lies in the central importance of the network idea for both Industry 4.0 and VCs, where a problem-related linking of real resources takes place [6]. VCs can optimize the entire value chain by restricting every company to its 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 IoT, and thus form a CPS: smart products, 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 [1]. Using real-time data, the network permanently updates the virtual image of reality. This enables the real world to merge with the virtual world [2]. 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 [1]. Taken to the extreme, Industry 4.0 is similar to an inter-organizational VC, which ideally also covers the entire value chain.

4.1.4 Self-Organization as the Overriding Principle

For a VC, self-organization is the most important principle next to process orientation, which is expressed in attributes such as “independent”, “self-optimizing” or “autonomous”. The emphasis on its importance culminates in the statement that a VC can only survive if self-organization largely replaces external organization by granting the system members great autonomy. Of vital importance for self-organization is the rapid availability of information across subsystems [7]. Self-organization increases flexibility considerably, promotes the dissolution of rigid structures and horizontal and vertical boundaries and ultimately creates a VC.

Self-organization also plays a central role in Industry 4.0. It enables decentralized, self-sufficient and self-optimizing production processes and supports companies in avoiding waste, thus achieving increased resource efficiency [1]. A CPS erects networks autonomously in order to optimize itself. The individual elements communicate and network with each other via the IoT. Many machines and systems are self-optimizing. Self-organization even goes so far that the machines independently inform about their maintenance status or initiate necessary maintenance work themselves in order to minimize waiting times and repair failures (“predictive maintenance”). 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. What has already been realized in the technological arena, especially within companies, can be globally organized between companies through the concept of the VC.

4.1.5 Consistent Process Orientation

A VU is also referred to as an „as-if“ organization since it has the possibilities and potential of a traditional organization without being tied to a comparable institutional framework [19]. Without the permanent implementation of central functions or hierarchical structures, an efficient process orientation can dominate over the organizational structure [10]. If external companies are involved in the creation of processes, it becomes increasingly unclear where one company ends and the other begins as the level of interlocking grows [6]. This approach thus leads to the dissolution of boundaries between companies. Without its own legal form, company headquarters and employees [5], a VC can adapt efficiently to market dynamics and rapidly changing customer needs.

In Industry 4.0, companies retain their legal form, headquarters and identity. However, these companies still rely on the same principles of process orientation. The value-added process is continuously monitored online so that, e.g. deviations are detected and automatically corrected within the ongoing production process. By networking all value creation processes in real time, the original conflict of goals between efficiency and flexibility is eliminated. This even enables flexible and efficient production in lot size 1 [1].

This resolution of the trade-off between efficiency and flexibility also characterizes the VC concept - even though existing VCs could not keep this promise at the time. Implementing the VC
design principles of dynamic allocation and self-organization brings about fundamental changes in the overall organization of Industry 4.0 companies: Cross-divisional thinking also leads to the reduction or elimination of indirect divisions, i.e. the supporting functions – and makes an Industry 4.0 company increasingly resemble a VC. Radical cross-divisional thinking can be an important contribution of the VC concept for Industry 4.0.

4.2 Challenges for a Further Common Development

If one wants to enrich Industry 4.0 with the principles of the VC concept, certain challenges have to be overcome in order to find a promising path towards an overall concept.

4.2.1 Selection of Core Competencies

If core competencies of companies are to be networked in order to generate synergies, the selection process of the cooperation partners plays an important role. It results in "initiation costs" and later in "coordination costs" during the period of cooperation. These costs must be kept low. The computer-assisted supplier selection processes already used in Industry 4.0 serve as important tools for global sourcing. The criteria only need to be adapted to the needs of VCs. It is crucial whether the core competencies to be selected are really complementary and thus will realize synergy effects. It is equally important to check the corporate cultures of the potential network partners for compatibility. It is also advisable to carefully study the difficulties often observed in failed or difficult mergers in order to achieve successful networking and avoid those mistakes.

4.2.2 Multitude of Interfaces

In Industry 4.0, many technical interfaces have to be mastered. The following standards should be used for secure, cross-company communication in virtual networks [20]:

- *Automation ML*: Automation Markup Language as a neutral, open data exchange format.
- *eCl@ss*: A consortium standard managed by the eCl@ss association.
- *OPC UA*: Open Platform Communications Unified Architecture, an open interface standard published as standard IEC 62541.

For the networking of different areas outside the company, as it is typical for VC, the OPC UA approach has the greatest potential. Its advantage is that it is a manufacturer-independent information model, which is essential for integrating the VC concept into the Industry 4.0 approach. Only the necessary IoT platforms yet to be developed will guarantee that the large number of technical, economic and organizational interfaces can be mastered.

4.2.3 Guarantee of Flexibility

Flexibility is mandatory when merging Industry 4.0 with the VC concept. All participants must be enabled to use the size of the network without having to give up their own flexibility and manageability [16]. Only then, economies of scale and experience curve effects can be realized without having to accept the inflexibility of a large company [19], and the individual companies can remain relatively small yet together achieve a considerable virtual size [17]. This is of particular interest for consortia of SMEs.

4.2.4 Realization of Time Advantages

Care must be taken to make sure that, in the integration of VC concepts into the environment of Industry 4.0, the theoretical time advantages through rapid adaptation to the market and to quickly changing customer needs are actually realized. For example, time-consuming processes, such as partner searches, must be solved with computer-aided software.

4.2.5 Remuneration and Protection of Intellectual Property

In a network linking Industry 4.0 employees to form a VC, clear rules must be agreed upon for the remuneration of all employees and for the use of intellectual property. It would seem sensible to extend the provisions of the Employee Invention Act to all employees and to regulate remuneration fairly everywhere.

4.2.6 Role of the Human Being

People play an important role in Industry 4.0. They must collaborate responsibly in teams. If man is to become the conductor of the value chain [1], she/he must constantly adapt processes to changing conditions, redefine value chains and generate new business models. However, management tasks in the Industry 4.0 environment have become more demanding. According to a study by the RWTH Aachen University and VDMA, the following five fields of action were identified, which must be taken into account for innovations in digital products, processes and services [21]:

- **Designing Innovation Portfolios**: The aim is to strengthen the ability to innovate. This can be done by cooperating with start-ups, universities or other business partners. In this respect, communication within virtual networks of VCs can be an important driver of innovation.
- **Overcoming Tendencies of Persistence**: Every innovation initially meets with resistance. This can be overcome with joint projects within the company (cross-departmental) or together with external partners in the VC.
- **Building an Innovation-friendly Culture**: When recruiting employees and selecting managers for Industry 4.0 and VCs, the decisive criteria should be their enthusiasm for innovation and new approaches, for flexibility and openness.
- **Building Digital Skills**: Training should further develop the ability to analyze data in Industry 4.0. Given their experience, employees of VCs can provide important input. This will also strengthen the cohesion between employees in Industry 4.0 and in VCs. When hiring new employees, special attention must be paid to digital skills.
- **Exploiting Digitization Potentials**: Often employees are not aware of the advantages of digitization. Above all, the customer benefits of digitization must be elaborated and communicated. As a result, digitization will gain acceptance both within and outside the companies and their virtual network.

The demands on employees in VCs are not lower: In addition to in-depth specialist knowledge, they must be able to manage and motivate themselves to a large extent, have strong communication and social skills and a confident command of new communication technologies [10]. Managers working in Industry 4.0 can support employees of VCs by providing targeted mentoring and training. This also conveys a feeling of solidarity and cooperation, which often doesn’t exist in VCs.

VCs carry the risk that teleworking will result in less traditional, permanent employment relationships. As a result of performance-based recruitment and remuneration, each employee is fully responsible for the company but enjoys little material security. There is also a latent danger that employees within the (compared to Industry 4.0 short-term) VC network will look for other job offers.
that seem more attractive or will be poached by headhunters. A more solid network in an Industry 4.0 environment achieves a bond with the company more easily. Joint projects, congresses, symposia, training courses, trade fairs and educational trips also can create a sense of belonging to the company. In addition, employees can be supported in their personal development or gain material advantages through possible profit sharing in successfully implemented projects. To sum it up: The personal appreciation of VC employees plays a decisive role. And the activities in Industry 4.0 and VCs should be aligned to a common corporate goal that is worthwhile for all partners. The combined Industry 4.0 and VC networks should also offer suitable promotion and career opportunities for ambitious employees.

The trust of the partners is one of the decisive factors for the success of the cooperation between employees in Industry 4.0, even more so in VCs. This trust must be strengthened by appropriate measures, as presented in this section. Applied correctly, Industry 4.0 fully exploits human and technological potential and combines them in an ideal way [2]. For instance, if the principles of ergonomics in the workplace and occupational safety are observed, it becomes possible to keep older and more experienced workers as active factors in the production process for much longer.

5. Conclusion

Industry 4.0 has already found its way into many companies and will continue to establish itself, including small and medium-sized enterprises. This strong concept is almost exclusively technological. It shows the technical state of the art of industrial production and its networking with suppliers and customers. It also describes how the requirements of dynamic and global markets can be satisfied. Above all the global orientation, the increasing individualization of requirements of dynamic and global markets can be satisfied. Above all the global orientation, the increasing individualization of requirements. The more important value creation by new digital products and the different requirements of customers on national and international markets as well as the tendency towards ever smaller batch sizes, up to batch size 1, require efficient, fast and flexible production with high quality at attractive costs. This means that a high degree of complexity must be mastered within the companies. This requires the highest efforts in the technical area which can be provided by the Industry 4.0 concept.

The Virtual Corporation provides a completely different perspective. At its core is not as much technology but the organization of many networked elements. What both Industry 4.0 and VCs have in common is that they rely on a powerful ICT. With cost-effective and powerful network connections, it is possible to attract the world’s best specialists and their core competencies to meet the current and future needs. This network of competencies creates products that are flexible, cost-effective and tailored to the customer’s needs. In order to achieve this, a company does not have to hire employees permanently for each requirement, but can bring in the appropriate people as needed. Because of the many additional specialist skills, the core company is perceived virtually as much bigger than it actually is because of its increase in performance. Thereby, it becomes a Virtual Corporation.

Industry 4.0 and Virtual Corporations have many similarities. Special efforts are required to combine both concepts in such a way that success is achieved in the highly competitive international market. With the exact knowledge of the characteristics of Industry 4.0 and Virtual Corporations, strategies can be created how the technical view of Industry 4.0 and the organizational view of Virtual Corporation can be combined in such a way that a successful and synergetic overall concept can be created for all sides. An important task for the future is therefore to further develop this overall concept and adapt it to today’s conditions and requirements. The more important value creation by new digital business models becomes and the more cross-company collaborations represent daily practice, the more urgent this task will become.

6. References