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Governance of Inter-Organizational Research Cooperation

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***Abstract*—**Companies face increasing challenges in research due to higher costs and risks. The intensifying technology complexity and interdisciplinarity require unique know-how. Therefore, companies need to decide whether research shall be conducted internally or externally with partners. On the other hand, research institutes meet increasing efforts to achieve good financing and to maintain high research reputation. Therefore, relevant research topics need to be identified and specialization of competency is necessary. However, additional competences for solving interdisciplinary research projects are also often required. Secured financing can be achieved by bonding industry partners as well as public fundings. The realization of faster and better research drives companies and research institutes to cooperate in organized research networks, which are managed by an administrative organization. For an effective and efficient cooperation, necessary processes, roles, tools and a set of rules need to be determined. Goal of this paper is to show the state-of-art research and to propose a governance framework for organized research networks.

***Keywords*—**Interorganizational cooperation, design of network governance, research network.

I. Introduction

COMPANIES face increasing challenges in research due to higher costs and risks. New competitors rise in the emerging markets in Asia and Latin America [1], [2]. To ensure competitiveness western companies need to stay innovative [3]. Sophisticated customer requirements and the desire for individualized products lead to an increase of product customization [4], [5]. To meet these requirements, new and innovative technologies are needed, but which often make interdisciplinary and unique know-how necessary. However, for such highly interdisciplinary technology development tasks, individual companies cannot maintain all the necessary human and technological resources [6]. Acquiring new skills, which do not match the company's core competencies, may not even be efficient [7]. Therefore, access to external knowledge by cooperation with partners becomes essential for the technology innovation process of companies [8], [9]. Likewise, research institutes face challenges and competition regarding high research reputation and secured financing [10]. In order to achieve high-level research a specialization of competency is necessary. However, at the same time interdisciplinary research topics require a variety of various skills. For research institutes a long-term cooperation with industrial partners is desirable in order to conduct application-oriented and relevant research and achieve financial planning reliability by third-party funds. [10]. Due to these factors, the cooperation with industry firms and other research institutes is essential for research institutes. Research networks offer compared to bilateral cooperation a wide range of various competences, which allow complex technology development and knowledge transfer. Pooling the expertise of industry and research enables the provision of holistic and consistent solutions [11]–[13]. Therefore, joint research and development activities in networks contribute a major share to business' value creation process and represent an important strategic tool for preserving the competitiveness of companies [14], [15].

A Europe wide benchmarking study, conducted by Fraunhofer Institute for Production Technology IPT in 2013, illustrates that successful companies rely mainly on cooperation with research institutions, customers, suppliers and also with neutral companies [16]. A subsequent benchmarking study from 2014 shows that 63% of companies conduct an network management and want to build-up their networks systematically [17], see Fig. 1.

II. Challenges of Network Governance

The need for cooperation in research networks for technology development is significantly, which leads to an increasing initiation of research networks in the last years [9], [18]. However, the failure of cooperation is even more likely than their successful permanent implementation [15], [18], [19]. The failure rate even increases with the number of participants due to the simultaneous pressure in terms of the development of complex technologies and the challenge of network management [20]. These challenges result in an uncertain research quality as well as in increased costs in network operation, which can lead to further unexpected high expenses [13], [20]-[22]. A delayed delivery of research results can lead to longer product development times and later earnings. This can weaken the competitive advantage and profitability of companies [20].

In practice, an efficient network organization plays an important role and influences the participation of companies [15], [23], [24]. In organized networks, network processes are standardized to use time and available resources of the network more efficiently. To do so, an organizing focal (central) entity performs the administrative tasks [15], [23]. In

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the context of research networks, this means that a focal entity, mostly university, organizes the operation and governance of the network. The incentive for a successful research network can be enhance when the focal entity is rewarded with a premium for acting as a provider towards the other network partners. The network partners profit from the coordinated network activities, whereby a premium for being part in the network can be justified [12]. The attractiveness of the research cooperations in the network is crucial for companies in order to stay in the network and thus decisive for the long-term survival and the success of the network. However, the network participants have different objectives regarding strategy and cooperation [15], [23], [25]. The success of the network can therefore be affected by misconduct of individual partners. This can include a network outlet or opportunistic behavior, such as the planned and deliberate withdrawal of foreign know-how [20], [21], [26]. Secrecy and distrust can lead to an information asymmetry between the participants, which results in ineffective and inefficient network activities [27]. An important network characteristic is that the members of the research network are legally and economically independent of each other and want to maintain their entrepreneurial freedom [15], [25]. Therefore, controlling the participants of multilateral networks by a third party, like a focal entity, cannot be taken for granted [15]. This is a striking difference to strategic networks, representing vertical value networks, in which the control by a focal company due to economic links is possible [15], [25]. Therefore, the governance organization of research network faces the conflicting priorities regarding leadership and flexibility on the one hand [12]. By implementing leadership, efficiency is gained in the network, while at the same time flexibility for achieving effectiveness in the network is needed. On the other hand, conflicts between common network interests and individual company interests exist. Besides that, the cooperation results can be evaluated of different value regarding the perspective of an individual company or the common network [15], [28]. In Fig. 2 the trade-offs of network governance are illustrated. These trade-offs may jeopardize the success of a research network significantly. In practice, an unsystematic governance of the network can complicate and delay the initiation of cooperation projects, because the different objectives are not aligned and the suitable project model cannot be identified. Occasionally the initiation of cooperation projects in the network works out, but mostly not in the long term, cf. [15], [18], [19]. Over the long term the spirit of the early beginnings of the network must be kept alive. A good communication in the network is necessary to overcome, the illustrated conflicts. Thus, an effective and efficient organization management must systematically design, control, and develop the joint work in the network. Thereby, the cooperation of the network participants, the initiation of cooperation projects, the division of tasks and roles, as well as the monitoring and evaluation of the cooperation structure needs to be organized [14]. The central control and coordination of the network is therefore of particular relevance and plays an important role in the network cooperation [14]. In addition, the network governance becomes more complicated by the fact that the governance costs must be kept as low as possible in order not to use up the savings and cooperative network profits [15], [19]. In summary, the competitiveness and the success of the network correlate strongly with the performance of the governance organization [18]. In practice clearly defined roles, processes and a set of rules is missing in order to handle the challenges of network governance.

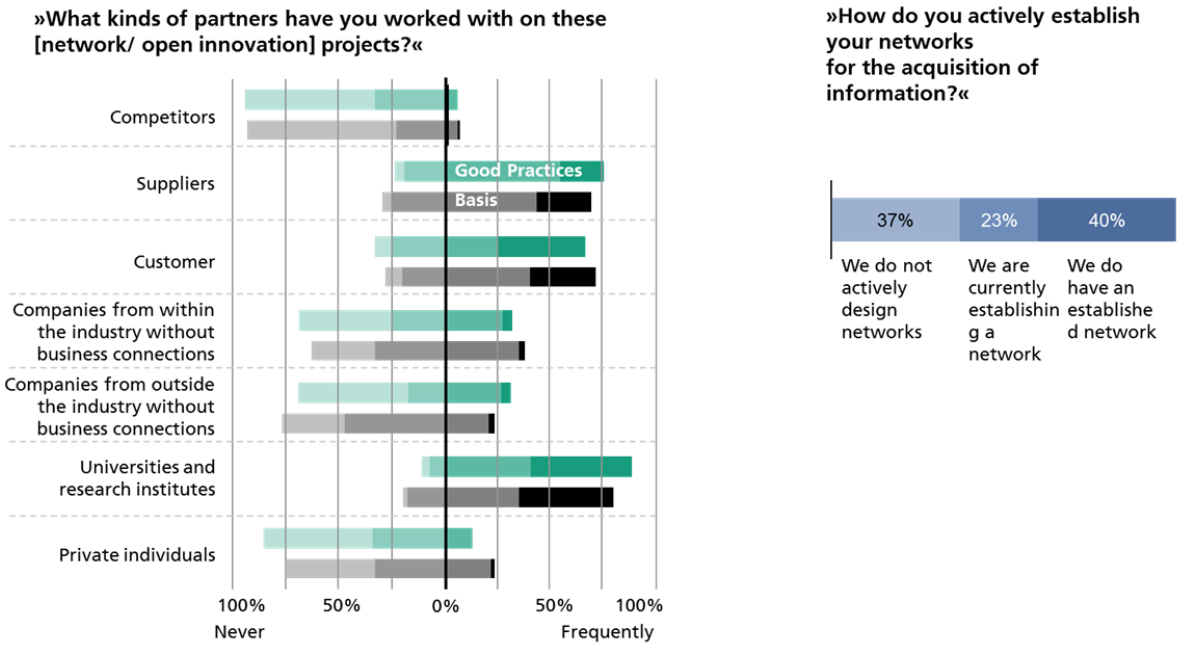

Fig. 1 Network cooperation in practice [16], [17]

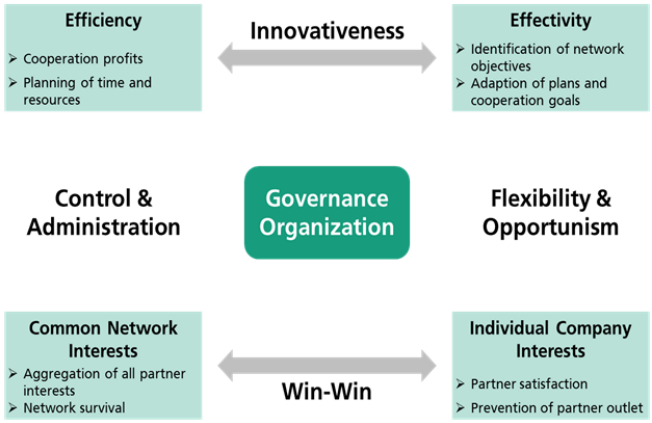

Fig. 2 Trade-offs of network governance

III. Literature Review

In literature, there is no holistic model, which enables network administrators to derive systematically an organization for operating and governing research networks in terms of long-term goals as well as the related procedures and resources to achieve these goals. For this research, literature is in particular relevant, which addresses governance rules and instruments and governance structures. Literature discussing roles in networks as well industry-university research cooperation, is also of high interest. Following, relevant works regarding the governance of networks are presented to show the state-of-the-art in literature and to motivate further research, see

TABLE I.

TABLE I
Subject Fields of Interest and Relevant Literature

Governance rules and instruments of networks	Dhanaraj and Pharkhe (2006) [28], Glückler et Al. (2012) [15]
Governance structure of networks	Provan and Kenis (2007) [23], Glückler et Al. (2012) [15]
Network roles	Schuh and Millarg (1998) [31], [32], Nollau (2014) [10]
Industry-university research cooperation	Ortiz (2013) [10], Nollau (2014) [20]

Dhanaraj and Pharkhe illustrate that network governance, or as they call it 'orchestration', consists of the three processes: managing knowledge mobility, managing innovation appropriability and managing network stability [28]. Managing knowledge mobility includes sharing, acquiring, and deploying knowledge and addresses facilitating common meeting places for learning and overcoming obstacles like tacit knowledge, epistemic barriers, lack of trust, diverging vocabulary etc. This way, social interactions for achieving trust, information sharing, and joint problem solving shall be enabled. Managing innovation appropriability involves the innovator's ability for capturing the innovation profits by recognizing and commercializing innovative ideas. Within managing network stability, the administrative hub firm, the orchestrator, can meet threats as isolation, migration, cliques, and attrition. Therefore, the network's dynamic stability is increased: by enhancing reputation, by lengthening the shadow of the future, and by building multiplicity in the network. According to [28], the hub firm can increase stability by developing its own strength through its reputation and leadership in the market. Because members seek the legitimacy given by links to the market leader. The shadows of the future can be created by illustrating the connection between current moves and future consequences. This motivates the members to remain in the network with the prospect of future gains. By conducting joint projects with network members, the hub firm increases the multiplicity and the scope of relationships. Such actions are coordinated by the administrative hub firm, which results in greater dependency and loyalty towards the hub firm. Thereby, isolation in the network can be decreased. This network stability prevents unstable linkages between network partners and encourages the company to cooperate [27], [28]. However, besides a set of rules for cooperation, [28] does not further detail how the processes and roles of the hub firm organization should look like in order to operate the network.

Provan and Kenis analyze the governance of organized networks and its influence on network effectiveness [23]. Thereby, it is distinguished whether the network is self-organized or organized by an administrative organization, the broker. Further, the brokered networks are distinguished in participant governed or external governed networks. Because self-organized governance can result in inefficiency, a single network participant most commonly acts as a lead organization, e.g. in vertical value chain relationships. For the external governed networks, a separate network administrative organization (NAO) is specifically created to coordinate the network and its activities. The NAO "may be either voluntarily established by network members or mandated as part of the network formation process" [23]. Due to the unique administrative structure of the NAO, a larger numbers of diverse participants can be handled in the network. Although the NAO acts as center of the network, the members still interact with one another like in the lead organization network. The NAO is preferred when working together is difficult because competitive pressures make network partners reluctant to cooperate and share information. NAO are more committed to network goals and are more involved in the future of the network. Provan And Kenis [28] formulate propositions to examine the conditions for the effectiveness of each form. Therefore, the tensions inherent in each form and the role of the management addressing these tensions are discussed. Provan And Kenis conclude "NAO network governance will be most effective for achieving network-level outcomes when trust is moderately to widely shared among network participants" [23]. Furthermore, NAO- and lead organization–governed networks achieve stability, whereas shared-governance networks allow more flexibility. Shared-governance networks realize more partner inclusion, whereas lead organization–governed networks enable efficiency. However, NAO-governed networks accomplish a balance between inclusion and efficiency. Furthermore, it is illustrated that shared governance networks evolve in their life to a brokered form [23]. Besides, the analyses of the influences

and benefits of a lead organization or a NAO in network Provan and Kenis do not further detail how the processes and roles within these organizations should look like in order to operate the network.

Glückler et al. analyse horizontal organized networks, which contains competing companies of the same value chain level [15]. Therefore, the competitive nature is the context of cooperation. Glückler et al. [15] analyse the link between the type of coordination and the innovation success. For this purpose, the coordination instruments self-alignment, centralization, and process standardization are examined in an empirical study. The analysis shows that the process standardization followed by the centralization has a strong influence on the innovation success of networks. Self-alignment, however, has only little influence, especially in more established networks. If communication only bases on self-alignment, from the perspective of an independent company no incentive for contribution to the common network objective exists [15]. The joint innovation work in the network can be regulated by rules to prevent fraud, opportunism and knowledge drain [28]. Furthermore, the existence of formal and binding processes acts positively on the successful work and the achievement of network objectives. Standardization can therefore lead to high innovativeness if formally processes ensure a smooth operation between the members to enable knowledge exchange and innovations [15], [29]. Glueckler et al. [15] therefore conclude that the central aspect of network governance is to standardize processes, responsibilities, and communication structures. Due to process standardization, time and resources can be used more efficient to promote innovation. Process standardization is therefore an indicator of successful cooperation networks [15]. Furthermore, Glueckler et al. [15] conduct an analysis of the most used controlling instruments and shows the relationships regarding specific network objectives. Based on that, the controlling instruments are categorized. In addition, Glückler et al. develop a method for analyzing the legitimacy of network governance structure, cf. [23]. Based on an empirical analysis Glueckler et al. [15] show that a deviation between planned and lived governance structure due the distribution of legitimacy exists. Thus, formalized governance structures like steering committees should also include informal but legitimate and accepted partners in the decision finding processes of the network. Neglect may even raise conflicts. However, besides the controlling instruments and the set of rules for governing, Glueckler et al. [15] do not go into detail regarding necessary roles and processes for the network governance.

Davidow and Malone illustrated in the 1990ies the virtual corporation [30]. Based on that, Schuh and Millarg introduce the Virtual Factory, which is a guided enterprise network in the form of a virtual enterprise in order to coordinate production [31], [32]. The intention of a Virtual Factory lies in the production of ordered products. The structural concept of the Virtual Factory consists of two levels: stable platform, which contains all network partners, and virtual factories, which are dynamic order-related, temporary value network. The entire Virtual Factory is coordinated by self-organizing forces. A focal network company that coordinates is not intended. The stable platform enables transactions regarding business or social nature between the participating independent companies. Based on the existing potential for cooperation enabled by the stable platform, the companies combine themselves depending on their competences in new dynamic order-related virtual factories. After the order processing, the virtual factories dissolve and the involved partners return to the stable platform. Therefore, the existence of the virtual factory is only temporary. The stable platform undergoes a continuous change, due to further development of individual companies, the optimization of links in the network and the integration of new companies as well as exclusion of existing partners. Schuh and Millarg [31], [32] also describe the needed roles within self-organization for the Virtual Factory. Main role is the broker that acquires new orders for the network. The competence-based configuration of the virtual factories is conducted by a performance manager. In-/outsourcing managers are responsible for communicating their companies' competences and capacities for use in the order-related virtual factories. The required stability during order processing of the activated network is ensured by the central role of the contract manager. The network relationships are managed by a network coach. An auditor examines the conducted work and watches the compliance of network rules. Besides these network roles, a process for the inclusion of new partners as well as a set of guidelines describing the quality of the order is illustrated. Further organizational details for operating the stable platform as well as the dynamic virtual factories are not described in detail. However, in newer research, Schuh recommends a focal management instance, which coordinates the Virtual Factory to enable more efficient work especially in terms of initiating cooperation projects [33].

Based on the Virtual Factory, Nollau presents [20] a concept of the virtual technology development enterprise, which combines order-related a specific pool of partners to conduct an interdisciplinary technology development for a customer [11]. The order confirmation as well as the configuration of the project partner pool is coordinated by a focal entity of the network, the central coordinator (broker). The central coordinator also has the central decision-making authority as well as the responsibility for the success of individual projects. Therefore, the central coordinator also assesses the companies for becoming partners in the network. The network partners also have codetermination in terms of a pool committee and project steering groups, but are mostly responsible for conducting the actual technology development. Nollau [20] further describes how based on competence profiles the suitable partners are selected for the specific technology project. In addition, Nollau [20] describes the development process within the cooperation project. However, the operating organization like processes for strategy alignment or controlling as well as well necessary tools of the focal entity are not further described by Nollau [20] as well as Schuh [33].

Ortiz analyses the structural features, which characterize the cooperation between universities and companies in regional innovation systems [10]. The research bases on the cooperation management instruments: selection, allocation, regulation and evaluation [10], [25], [34]. These instruments Ortiz classifies further regarding the regional innovation system between universities and companies. Each mechanism is analyzed regarding the influence for companies, university and regional innovation systems like networks. Regarding the regulation of regional industry-university innovation system Ortiz [10] identifies the spatial proximity allows a more effective and efficient management process due to the direct alignment between decision-makers, especially in terms of readjustments of cooperation projects. Thereby, possible conflicts can be avoided. In addition, a central specialized organization for coordination tasks is proposed. Thereby, a harmonization of the cooperation relationships in the network can be achieved [10]. However, besides a set of rules how regional innovation systems can be regulated, Ortiz does not further detail how the management in terms of processes and roles should look like.

In literature, the theoretical deficit regarding a systematic aligned governance framework with design elements exists because mainly the development of network structures as well as the motivation of the participants is focused. The governance and operation of networks, however, was been hardly addressed [15], [23], [25]. In existing literature, design elements for a process organization are rarely named. A superior framework of the governance organization for aligning the governance elements in terms of the requirements has only been studied sporadically in research [10], [23]. Therefore, a system is missing, which describes the requirements of the governance organization regarding the objectives and influencing factors. Furthermore, there is a lack of understanding the combination of design elements to a consistent governance organization, since the cause-effect relationships between the design elements and the requirements of a research network cannot be systematically justified.

IV. Design of the Network Governance Framework

The existing deficits in practice and scientific theory motivate the development of a framework containing design elements to define the governance organization of organized research networks. Goal is to reduce effectiveness and efficiency losses due to an unsystematic configuration of the network organization. The exact requirements for the governance of the research network are uncertain due to participant specific objectives as well as internal and external influence factors of the network [25]. An analysis of the influences of the network objectives and the network characteristics on the network governance is necessary to enable and guide network managers to combine the design elements of the governance elements regarding the network requirements. As consequence, trial-and-error approaches in practice shall be prevented [15], [23], [25]. Therefore, the cause-effective relationships between the governance framework and network requirements need to be identified in order to present possible governance types of organized research networks.

Based on the concepts of the virtual factory and the virtual technology development enterprise [20], [31], the concept of the organized research network consists also of a stable platform containing all network partners and purpose-related dynamic research cooperations with selected partners. The stable platform as well as the dynamic research cooperation is controlled by a focal entity, which is also an active part in the research value creation process. Within the stable platform, the partners align together the research strategy and select topics for dynamic research cooperations. The focal entity coordinates and guides the consolidation of the individual efforts in the network into a coordinated system [12], [23], [15]. The focal entity needs to conduct a systematic network management to harmonize the activities of network partners and thereby to guide different identities and objectives into the direction of the overall network goal. By a strong involvement of the network partners in the operation of the network all partner interests can be considered, which results in a high attractiveness of the network.

Suitable actions of the governance framework can be derived from the presented literature as well as in combination with the management dimensions of network cooperation management according to Bleicher and Beer [35], [36]. Thereby, four management dimensions can be identified, see Therefore, for operating organized research networks the following governance framework is proposed, see Fig. 3.

TABLE II. Therefore, for operating organized research networks the following governance framework is proposed, see Fig. 3.

TABLE II
Management Dimensions and Governance Actions

Management dimension	Governance action
Normative management	Set of rules
Strategic management	Processes and Tools
Tactic management	Processes and Tools
Operative management	Roles

The proposed governance framework consists of four action fields: »processes«, »roles«, »tools and resources« as well as »set of rules«, cf. [14], [37]. Between these four fields relationships exist, which need to be identified in order to clarify the needed effort and the achieved benefit in network governance.

The field »processes« describes the superior governance process. This process illustrates a cooperation cycle within the network consisting of three steps. Within the process step »cooperation planning«, processes for aligning the short-term and long-term strategy of the research network, for selecting the cooperation projects as well as for budgeting the different cooperation projects need to be considered [38]. In the step »cooperation execution« different cooperation models are described and selected regarding the cooperation needs. The models depend on requirements like maturity level of the

technology development. For instance, for trend topics, like Industrie 4.0 or Additive Manufacturing, with an early maturity level, consortium studies or working groups are most suitable. Whereas for technology developments with a high maturity level a pool of specific partners is selected, because such developments are mostly competitive relevant and therefore not all network partners are allowed to join. Depending on the kind of cooperation projects different intellectual property (IP) regulations and cooperation process, like stage-gate or agile, are necessary. In the step »cooperation review«, the processes for controlling the cooperation results, for aligning new topics for the next project planning as well as for risk management are considered.

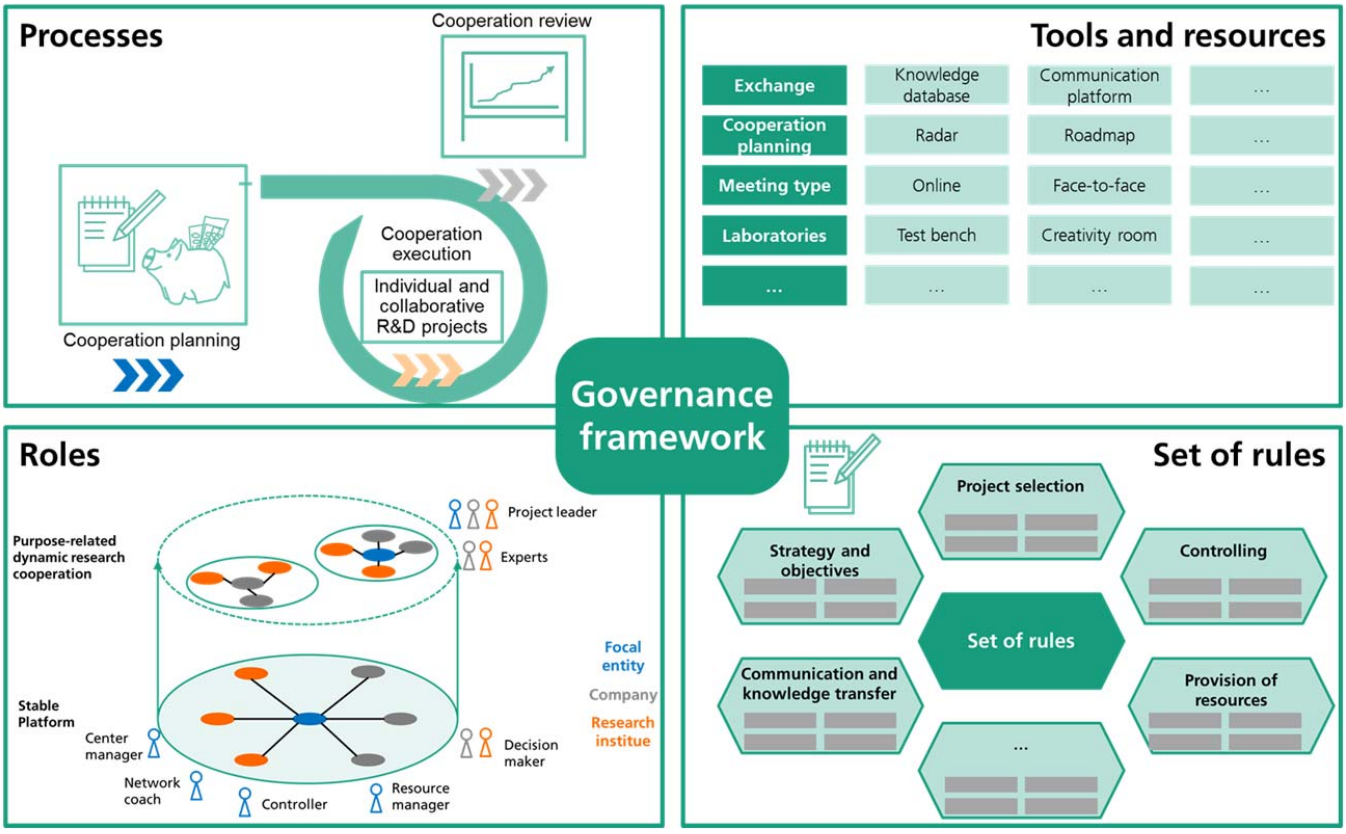

Fig. 3 Governance framework and elements for operating research networks

In the field » roles«, the responsibilities within the network are described and roles are derived [8], [39], [32]. Therefore, the levels stabile platform and purpose-oriented cooperation need to be analyzed individually. For the stabile platform, in which the cooperations are planned and reviewed, potential roles of the focal entity could be center manager, networking manager, controller, as well as mangers for allocating resources to the cooperation projects or acquisition of public fundings. Roles of the other network participants could be decision-makers. For the purpose-oriented cooperations the roles of the project manager and the experts can exist.

The field »set of rules« describes the way of network governance regarding strategy alignment, feedback gathering, partner care, reporting etc. In addition, a code of conduct describes the way of behavior during network cooperation. The set of rules shall act as behavior code to suppress "short-termed opportunity actions of individual network partners" [12]. Furthermore, the specific rights and responsibilities of the network participants (focal entity, research institutes, and companies) are documented. Especially, from the research institutes a strong commitment regarding their cooperation and resource contribution in the research network is necessary.

The field »tools and resources« describe the measures to implement the processes, roles, and rules. These measures can be management tools like social platforms, knowledge databases, roadmaps, or monitoring radars [40]. In addition, existing resources like laboratories, machines, or offices need to be managed. Due to a larger number of network participants, time is also a resource. Therefore, it needs to be discussed for what cooperation elements face-to-face or online meetings are necessary, e.g. for budgeting an online alignment may be sufficient.

The presented governance framework shall address all necessary processes, roles, tools, and rules in order to operate a research network consisting of multilateral partner. The structural organization of the network in terms of partner number and size as well as their motivation for network participation shall not be addressed by this framework.

V. Summary and Discussion

Increasing costs and risks in research and development in combination with the requirement of unique interdisciplinary know-how make research cooperation of companies and research institutes necessary. As consequence, companies and research institutes cooperate increasingly in organized research networks, which are controlled by a focal entity. Objective of the focal entity is to conduct the administrative tasks and to organize processes within the network in order to prevent network failure. The network activity can be affected by various conflicts due to independent companies with different goals, which focus at first their own interests and not the common network interests. Therefore, a governance organization plays an important role in order to achieve an effective and efficient research network.

Within this paper, a literature review of relevant research regarding the governance and process organization has been presented. Mostly in literature, different types of governance and organization structures as well as set of rules are analyzed. Design elements in terms of processes and roles for a governance organization are rarely named. A superior framework of the governance organization for aligning the governance elements in terms of the requirements has not been in the research focus. Based on the existing literature, a governance framework, consisting of the four fields »processes«, »roles«, »tools and resources« as well as »set of rules«, has been introduced. Furthermore, possible organization elements of these fields have been illustrated.

In future research, the governance framework needs to be further detailed. All relevant elements need to be identified systematically. In addition, the network requirements regarding the influencing factors of the network characteristic and the network objectives need to be identified. Lastly, the cause-effect relationships between these elements can be examined. Thus, different types of network governance organization can be derived, which supports network officials to coordinate their individual organized research network.

References

[1] Braun, D. Holtmannspötter, S. Korte, S. Rijkers-Defrasne, and A. Zweck, Technologieprognosen. Internationaler Vergleich 2013. Düsseldorf. Zukünftige Technologien Consulting, 2013.

[2] G. Schuh, M. Graw, and N. Schön, "Exploitation-oriented Manufacturing Technology Development," Procedia CIRP, vol. 17, pp. 680–685, 2014.

[3] M. E. Porter, The Competitive Advantage of Nations. Harvard Business Review, 1990.

[4] G. Schuh, J. Arnoscht, A. Bohl, and C. Nussbaum, "Integrative assessment and configuration of production systems," CIRP Annals - Manufacturing Technology, vol. 60, pp. 457–460, 2011.

[5] S. Rudolf, Produktionsgerechte Baukastengestaltung. Aachen. Apprimus-Verl., 2013.

[6] J. Gausemeier, Augmented & virtual reality in der Produktentstehung. Grundlagen, Methoden und Werkzeuge; virtual prototyping/digital mock up, digitale Fabrik; Integration von AR/VR in Produkt- und Produktionsentwicklung. Paderborn. HNI, 2004.

[7] Nooteboom, Inter-firm collaboration, learning and networks. An integrated approach. London, New York. Routledge, 2004.

[8] Baumann, Konzeption hochschulnaher Innovationscluster. Aachen. Apprimus-Verl., 2011.

[9] M. Grochowski and P. Ohlhausen, "Cooperation models as success factor for interdisciplinary, inter-organizational research and development in the automotive industry,", pp. 270–279.

[10] Ortiz, Kooperation zwischen Unternehmen und Universitäten. Eine Managementperspektive zu regionalen Innovationssystemen. Wiesbaden. Springer Fachmedien Wiesbaden; Imprint: Springer Gabler, 2013.

[11] G. Schuh, M. Wellensiek, and S. Nollau, Management of a virtual technology development enterprise, 2010.

[12] G. Schuh, W. Boos, and U. Gartzen, "Design of a Rule-Based Network," International Journal of Systems Applications, Engineering & Development, 2011.

[13] S. Saetta, L. Tiacci, and L. Cagnazzo, "The innovative model of the Virtual Development Office for collaborative networked enterprises: the GPT network case study," International Journal of Computer Integrated Manufacturing, vol. 26, pp. 41–54, 2013.

[14] G. Schuh and A. Kampker, Strategie und Management produzierender Unternehmen. Handbuch Produktion und Management 1. Berlin, Heidelberg. Springer-Verlag Berlin Heidelberg, 2011.

[15] J. Glückler, W. Dehning, and T. Armbrüster, Unternehmensnetzwerke. Architekturen, Strukturen und Strategien. Berlin, Heidelberg. Springer Berlin Heidelberg; Imprint: Springer, 2012.

[16] Fraunhofer Institute for Production Technology IPT, Consortium Benchmarking Study "Technology Management". (not published). Aachen, 2013.

[17] Fraunhofer Institute for Production Technology IPT, Consortium Benchmarking Study "Technology Intelligence". (not published). Aachen, 2014.

[18] Ö. Sölvell, G. Lindqvist, and C. Ketels, The cluster initiative greenbook. (Stockholm, Sweden). Ivory Tower, 2003.

[19] S. H. Park and G. R. Ungson, "Interfirm Rivalry and Managerial Complexity: A Conceptual Framework of Alliance Failure," Organization Science, vol. 12, pp. 37–53, 2001.

[20] S. Nollau, "Die virtuelle Technologieentwicklungsunternehmung,", 2014.

[21] J. Zentes, Kooperationen, Allianzen und Netzwerke. Grundlagen - Ansätze - Perspektiven. Wiesbaden. Gabler, 2005.

[22] Gerybadze, "Management von Technologieallianzen und Kooperationen," in Handbuch Technologie- und Innovationsmanagement. Strategie - Umsetzung - Controlling. S. Albers, O. Gassmann, Eds. Wiesbaden, s.l.: Gabler Verlag, 2005, pp. 155–174.

[23] K. G. Provan and P. Kenis, "Modes of Network Governance: Structure, Management, and Effectiveness," Journal of Public Administration Research and Theory, vol. 18, pp. 229–252, 2007.

[24] M. Schwartz, F. Schiller, and L. Kramer, "TiCo: Technologiemanagement in Communitys. Ergebnispräsentation einer Onlinebefragung mit dem Ziel der Identifikation von KMU-spezifischen Präferenzen bezüglich Communitys," Udz - Unternehmen der Zukunft, vol. 15., 2014.

[25] J. Sydow, Ed., Management von Netzwerkorganisationen. Beiträge aus der \"Managementforschung\". Wiesbaden. Gabler, 2006.

[26] J. Fest, Controlling zwischenbetrieblicher Forschungs- und Entwicklungskooperationen. Eine lebenszyklusorientierte Konzeption. Aachen. Shaker, 2006.

[27] H. Gausdal and E. R. Nilsen, "Orchestrating Innovative SME Networks. The Case of "HealthInnovation"," J Knowl Econ, vol. 2, pp. 586–600, 2011.

[28] Dhanarag and A. Parkhe, Orchestrating Innovation Networks, 2006.

[29] J. Hauschildt, Innovationsmanagement. München. Verlag Franz Vahlen, 2004.

[30] W. H. Davidow and M. S. Malone, The virtual corporation. Structuring and revitalizing the corporation for the 21st century. New York. HarperCollinsPublishers, 1992.

[31] G. Schuh, K. Millarg, and Å. Göransson, Virtuelle Fabrik. Neue Marktchancen durch dynamische Netzwerke. München, Wien. Hanser, 1998.

[32] K. Millarg, Virtuelle Fabrik. Gestaltungsansätze für eine neue Organisationsform in der produzierenden Industrie. Regensburg. Transfer-Verl., 1998.

[33] G. Schuh and P. Wegehaupt, "Die Virtuelle Fabrik - Lessons Learned zehn Jahre danach," in Unternehmensnetzwerke. Fragen der Forschung -

Erfahrungen der Praxis. 1st ed. Inititative für Beschäftigung OWL e.V., Ed. Stücken: Kleine, 2004, pp. 117–127.
[34] J. Sydow and A. Windeler, "Über Netzwerke, virtuelle Integration und Interorganisationsbeziehungen," in Management interorganisationaler Beziehungen. Vertrauen, Kontrolle und Informationstechnik. J. Sydow, Ed. Opladen: Westdt. Verl., 1994, pp. 1–21.
[35] K. Bleicher, Das Konzept Integriertes Management. Visionen - Missionen - Programme. Frankfurt am Main. Campus, 2011.
[36] S. Beer, The heart of enterprise. Chichester (England), New York. Wiley, 1979.
[37] G. Schreyögg, Organisation. Grundlagen moderner Organisationsgestaltung; mit Fallstudien. Wiesbaden. Gabler, 2008.
[38] Gerybadze, Management von Technologieallianzen und Kooperationen. Stuttgart, 1999.
[39] L. Kramer and J. Brell, "Technologiemanagement mittels Experten-Communities. Das Forschungsprojekt »TiCo« erstellt einen Leitfaden für KMU," Wissenschaftsmanagement, pp. 22–25, 2015.
[40] G. Schuh and S. Klappert, Technologiemanagement. Handbuch Produktion und Management 2. Berlin, Heidelberg. Springer-Verlag Berlin Heidelberg, 2011.