# Distributed Innovation in Classes of Networks[1]

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## Abstract

*Rapid developments in digital technologies have brought to force new challenges in innovation. In this paper, we propose a taxonomic framework of innovation networks in order to identify new challenges. Innovation networks form socio-technical systems that exist in a distributed cognitive space. The generative processes in these innovation networks involve both cognitive and social translations. At the same time, the rapid developments of digital technologies have reduced communication costs and allow integration of previously unconnected activities and artifacts due to digital convergence. These two forces of digitization – reduction in communication cost and digital convergence – stretch the innovation networks in two dimensions. On one hand, we see an increasing distribution of control and coordination among actors participating in innovation networks. On the other hand, we also see an increasing heterogeneity in knowledge resources that are mobilized during an innovation. These two dimensions allow us to conceptualize four types of innovation networks that result from pervasive use of digital technologies: singular innovation, open source innovation, internal markets of innovation, and doubly distributed innovation networks. We discuss the implications of our conceptual framework for the evolution of information infrastructures, future innovation research based on network analyses, and the new interlacing of ontology and epistemology of innovations.*

## 1.0 Introduction

The increasing global competition has forced organizations to innovate constantly. Organizations need to identify, mobilize and integrate diverse pools of knowledge to design and deliver novel products and services. Often, these resources to implement such innovations will not reside inside a single organization and organizations need to form networks to share and co-develop necessary knowledge. Thus, organization's ability to overcome differences in ownership and governance, heterogeneity in knowledge bases and values, and peculiarities in vocabularies among participating companies can determine the success of the innovation. Organizations often use information technology in forming these networks with a hope to facilitate, speed up and reduce costs of knowledge sharing and to bridge differences in perspectives [10].

In this paper, we use the term innovation network to refer to socio-technical networks of organizations that enable innovation. We emphasize the socio-technical nature of the network as organizations in the network are connected and their activities are supported through various types of digital information technology. These technologies connect the members of the network and act as the fundamental layer of information infrastructure: a "shared, evolving, and heterogeneous installed base of IT capabilities among a set of user communities based on open and/or standardized interfaces" [21].

Any information infrastructure supporting an innovation network is rarely made of a homogeneous technology base. In contrast, it is an outcome of bricolage around heterogeneous technology resources that are sedimented over one another while organizations join the network and bring their own installed base that fits their own knowledge base. As such, the use of information technology to support innovation networks adds new complexities and dynamics while producing unintended consequences. Accordingly, an innovation network is often situated in a *doubly distributed system* where both organizational and technological controls are distributed among heterogeneous actors and artifacts.

Past research studying innovations through a network lens focuses primarily on the diffusion of singular innovations among homogenous firms. When network researchers apply the network perspective, they look at the structure of *social* networks in order to model knowledge sharing and learning and predict

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innovation outcomes. Rarely, do scholars ask how digital information infrastructures interact with prevailing social structures, and how these interactions shape the emergence of innovations.

In order to close this gap, we conceptualize innovations as a series of translations between ideas, representations and material realization of the ideas (either in the form of physical products or services), mediated through technology artifacts. These translations take place in a distributed cognitive space forming an innovation network. We discuss four different types of innovation networks and examine characteristics of information infrastructures that are essential in establishing successful innovation networks. We conclude our paper by discussing future research directions based on identified research challenges and new methodological considerations.

# 2.0 Innovations Networks

## 2.1 Past Research on IT-enabled Innovations

Past innovation studies have applied several ways to classify innovations [38, 40, 42]. They primarily conceptualize innovations at the level of individuals [16] or firms [5, 14, 17, 38, 51]. Diffusion of innovations is conceived as a linear, sequential process [5, 14, 17, 38], though recent studies have recognized the importance of feedback and the multiplicity of sources that affect innovation [39, 40]. Consequently, most IT innovation studies provide rich insights into adoption patterns of relatively homogenous innovations, but offer little insights into how IT innovations are often accompanied by other innovations such as economic, technological, or institutional ones. Moreover, these studies do not examine how IT innovations affect trajectories of other innovations within the network. Some recent studies about IT innovation within inter-organizational domains [29], or of a focal industry [42] are rare exceptions. Unfortunately, these studies focus primarily on populations of homogenous firms. Our work extends these prior studies by looking at innovations in doubly distributed socio-technical networks with heterogeneous actors.

Recently, students of innovation have began move away from variance models that identify key factors affecting the innovation "push" and "pull" [15, 34]. Instead, increased attention is heeded to innovation in networks [40, 41, 44, 47], and to understand innovation in doubly distributed systems such as architecture, engineering and construction industry (AEC) [9]. These studies point out that innovations emerge and diffuse through webs of a socio-technical networks. They stem from previous innovations, and enable or require further innovations, thus making innovation by necessity a distributed activity. When von Hippel defines functional sources of innovation he introduces the idea of a distributed innovation process as a system [43]. Accordingly, the distributed innovation process has been found to have much in common with nonlinear dynamic systems that are "neither stable and predictable, nor stochastic and random." They are also highly sensitive to path dependence [42]. Such distributed innovation processes result from a cooperative / competitive relationship among specialized nodes, in which "various actors and functions interact to create an infrastructure that both facilitates and constrains innovation" (P.179). Our study draws on the framework of a distributed system of innovations, and extends it by combining it with the enabling features of a distributed IT architecture.

Theories of social construction of technology posit that innovations depend on contexts established by technologies, actors and organizational forms [8, 28, 49]. Innovations are not neutral as they reflect social beliefs and values that are shaped by institutional mechanisms [27]. An innovation theory that builds on this perspective explains how social contexts influence and become embedded in technologies, how transformations take place in social networks, and how interpretations of technology stabilize. Yet, we feel that this approach is inadequate to account for the wake of heterogeneous innovations that was observed in multiple pockets of an innovation network [7]. In a recent study of innovation in AEC industry with 3D technologies [9] no singular closure of technological frames, nor an irreversible actor network was observed contrary to the suggestions of these theories.

Finally, a growing body of innovation research has begun to shift from studying a single innovator to examining distributed and amorphous networks of heterogeneous actors [40, 41]. When innovation is distributed and takes place among heterogeneous actors, it is affected by network effects, messiness, ambiguity, and combinability [29, 40, 41]. The innovation arena becomes dynamic and volatile, and is subject to political influence, and transpires across multiple communities. Accordingly, innovation scholars have paid attention to communal and networked features of innovation [11, 46] by showing that increased network diversity promotes new combinations, fosters learning and enables faster diffusion [40]. At the same time diversity builds thicker learning boundaries which inhibit the spread of innovations. As a result, innovation scholars are beginning to examine in more detail types of interactions mediated by different IT artifacts [13] and affected by different network topologies [1, 33] that can foster distributed innovation among packs of innovators [41]. This helps understand how varying network configurations facilitate combinations of new knowledge while communities expand and crisscross [40]. In our prior work, we saw such interactions in the innovation networks as the *modus operandi* when an architect introduced a new 3D representation tool in construction projects [7]. Yet, most earlier studies have examined interactions and knowledge sharing between at most two communities, or within a single firm [7]. Moreover, these studies primarily concentrate on structural features of social networks [1, 33] paying little attention on the role of technology in facilitating interactions in an innovation network that spans across professional communities [10].

## 2.2 Two Dimensions of Translations in an Innovations Network

Innovation is simultaneously cognitive and social. It is cognitive in that it involves creation of new ideas that need to be translated through a series of representations before they can become materialized in new products and services [3, 36]. We refer to this as *cognitive translation*. The translation of ideas into representations and eventually into artifacts is not necessarily linear. Instead, it is iterative and messy, filled with surprises and disappointments. Yet, in most cases, cognitive translations progress with a sense of direction of moving forward. In this generative process, innovators deploy various tools and artifacts that assist in the translation as to make their own perspective known to others [10].

Innovation is also inherently social. The translation of ideas takes place through distributed cognition that is enabled and supported by heterogeneous artifacts [6, 22, 24, 25]. Relationships among actors are mediated by artifacts, many of which are increasingly digital [9, 13]. The more diverse the actors are, the less likely it is that actors are previously connected in a single network. Accordingly, the more radical and novel the innovation is likely to be, the more difficult it is to connect these actors.

Connections among individuals are *complementary, dialectical* and *dialogical*. When the connection is complementary, the innovation is created by combining two previously unconnected communities [22]. Often, such an unlikely connections are made through individuals who occupy a “structural hole” or a “weak link” [12]. When the connection is dialectical, the innovation occurs through a Hegelian synthesis of two opposing perspectives through an unlikely link [13, 37]. The innovation from a dialectical view point is likely to be radical and discontinuous as a result of transformative generative process when the synthesis is produced. Finally, when the connection is dialogical, tensions between the individuals are never-ending and discursive. In dialogical connections, each side must assume the other side to exist and there is constant interplay between the two [23]. Therefore, the innovation from a dialogical relationship is dynamic and evolving. For example, in the AEC industry, tensions between design and construction communities form a primary source of innovation. Through these types of connections, another set of translations takes place in networks, which is different from the aforementioned cognitive translations. We refer to these as *social translations.* They take place at the boundaries of communities where individual actors negotiate and mutually adjust to other’s perspectives. These translations are also inherently political and take place in the “trading zone” [9, 26]. Furthermore, while the cognitive translation remains progressive, social translation can be thought of as a series of back-and-forth movements of influence among actors.

Although for the purpose of analysis we separate cognitive and social translations in an innovation network, they are tightly intertwined in the practice. The cognitive translation constrains and is constrained by the social translation. The cognitive schemata, mental models and scripts that underlie the generative process of innovation are socially constructed [6]. Therefore, the very act of cognitive translation is inherently social. At the same time, the cognitive translation of ideas into representations and into artifacts involves more than one actor. Whilst an idea moves forward to become a reality (in the form of new services and products), multiple actors from different communities get involved. For example, in a typical construction project, an architect’s ideas captured in architectural drawings (a translation from an idea to a representation) are later translated into detailed engineering drawings (a translation from a representation to another representation). In this process, engineers not only map one type of representation to another type, but they also add their own perspective, and expand the depth of knowledge embedded in the artifact. Similar translations take place while engineering drawings get translated into shop drawings and eventually materials and components and finally into the building through the labor of contractor, subcontractors and fabricators. In this series of translations both cognitive and social translations co-exist and are essential in shaping the innovation.

Both sorts of translations are increasingly mediated by digital technologies. Various decision support tools and design assist tools e.g. CAD were originally designed to support the cognitive dimension. Likewise, coordination tools such as collaborative tools, repositories, and communication technologies (e-mail) facilitate and mediate the social dimension. In the IS literature, these two classes of tools are often treated and studied separately with a rare exception of Malhortra et al. [31]. As the two dimensions of translation are inherently intertwined, the digital technologies that are designed to support these translations also need to reflect this duality.

### 2.3 Two Drivers of Digitization in Innovation Networks

The current developments in digital information technologies have brought significant changes in the way innovation networks are shaped. The phenomenal success of the open-source software projects like Linux and Apache has demonstrated that thousands of voluntary programmers with minimum central control can deliver reliable and robust software. It is even more remarkable when we consider the fact that these software systems, designed and maintained largely by distributed volunteers, take up the majority of the servers on the Internet. The success of such distributed innovations is not constrained only to the software development domain. Many organizations are busy to find ways in which they can harness user innovation [45]. Radically departing from the conventional top down and sequential model of innovation, many firms seek new forms of collaboration and joint exploration [41]. Much of these distributed innovations depend on reduced cost of communication and coordination due to the developments of information technology. The key challenge here is how to manage the *distributed* nature of the coordination and control.

While the distributed and coordinated nature of innovation has received a growing attention, another dimension - digital convergence [30] - of information technology change has not been widely recognized. As information technologies transform all analog information into a unified digital format, previously unrelated information can now be easily manipulated and combined to create new families of representations. For example, so-called 'triple-play' (combining broadband internet, phone and TV services) or 'quadruple-play' (adding mobile internet) are becoming major disruptions in media and communication industry. The challenge of digital convergence is not limited only to knowledge products. The recent collaboration between Nike and Apple in combining Nike's running shoes with Apple's iPod is enabled by RFID (radio frequency identification) chips embedded in running shoes which then communicate the digitized information of running patterns to the recorder in an iPod via Bluetooth. Once returning home, the runner can upload the recorded information of the workout on a dedicated website for further manipulation. Similarly, the increasing use of GPS chips in digital cameras and mobile phones, combined with comprehensive digital maps and physical buildings with sensor networks, spur stream of novel services and products that connect previously unconnected experience. Also, in the AEC industry, the new tools allow users to digitize not only the drawings, but also other aspects of project management such as cost, risk and time, again connecting previously unconnected aspects of construction together, creating new type of innovation networks. Each time new connections are made between previously unconnected communities, each actor is likely to bring his or her hard won technology bases and unique knowledge resources that support their work. Therefore, the key organizational challenge here is how to manage *heterogeneity* of knowledge resources and tools and expand the information infrastructure [32].

We contend that the two factors -- distribution of control and coordination by the reduction of communication cost and increased heterogeneity of knowledge resources amplified and enabled by digital convergence – form the two underlying forces that shape networks of innovation.

## 3.0 Four Types of Innovation Networks

The two forces of digitization of innovation networks, combined with two types of translations, allow us to conceptualize four types of innovation networks. On one dimension, we consider the different degrees of distribution of coordination and control over various actors in the network. On one end of the extreme, we see a complete centralized control over all actors. Typically, this could be an innovation that involves individuals working for a single firm who participate in top-down innovation initiatives. On the other extreme end, we see a decentralized control and coordination. An example of this extreme would be an open source community or a loosely coupled industry association working on a joint innovation project (e.g., fuel cell research group).

| | | Distribution of coordination & control | |
|---|---|---|---|
| | | Centralized | Distributed |
| Heterogeneity of knowledge resources | Homogeneous | Type A Singular Innovation | Type B Open Source Innovation |
| | Heterogeneous | Type C Internal Market of Innovations | Type D Doubly Distributed Innovation Network |

**Figure 1. Four Types of Innovation Networks**

In the second dimension, we consider the degree of heterogeneity of knowledge resources. On the one end, we have a single homogeneous technology platform. On the other end, we have a hodgepodge of heterogeneous technologies and tools. The combination of these two dimensions allows us to conceptualize four different types of innovation networks. Below, we will discuss each type in more detail.

### 3.1 Type A: Singular Innovation

This is an innovation network where both cognitive and social translations take place within a confined context of centralized organizational control and coordination is supported through homogeneous knowledge resources. Incremental efforts within an organization or a community with a tight net will fall into this type of innovation network. Process innovation efforts for TQM or ISO9000 that are driven by a singular organizing vision and supported by a homogeneous set of tools are good examples. Innovations that focus on a particular subsystem embedded into a larger system also fall into this type. As individuals in this type of innovation network share similar perspectives and use similar language, social translations in this network are likely to be less problematic compared to other types of innovation networks. The role of technology resources in cognitive translations is more pronounced.

### 3.2 Type B: Open Source Innovation

A classic example of this type of innovation network can be found in open source communities. Here, the individual actors are not bound by the centralized control. They act based on their own self-interests and self-initiatives. Yet, most actors are working on a relatively homogeneous technological platform, or they confirm to a strong form of standards. The social translations are most likely based on complementary connections as individuals often contribute to different parts of the innovation that can later be combined. The radical reduction of communication cost enables distributed division of labor that can be digitized [47]. Therefore, the innovations originating from this type of network are likely to be economically more efficient when compared to other types.

### 3.3 Type C: Internal Market of Innovations

In this type of innovation network, individual actors are under centralized control, often within the realm of a single hierarchy. Yet, within the single organizational boundary, there exist many diverse communities of knowledge that may be connected either formally or informally to the external organizations. As members of the internal communities strongly identify and associate with external professional organizations in terms of their knowledge and expertise, it is likely that they maintain their own unique set of knowledge resources. These internal communities of knowledge have often minimum knowledge sharing inside as the organizational boundaries exist in the legal and financial sense. A good example of this type of innovation networks can be found in many multi-divisional large firms that try to provide integrated solutions or services [19, 35]. For example, IBM has gone through radical restructuring in order to become an “IT service” company. Under this new regime, IBM’s interactions with its customers are streamlined primarily through its consulting division, which orchestrates knowledge and resources from different communities within IBM, such as software, hardware, telecommunication, design and research. Many consulting firms also face similar challenge. Similarly many traditional industrial firms like ABB, Parker Hannifin and Rockwell Automation face customer demands to deliver integrated solutions instead separate components, many of which come from separate business units within the same company. As these firms have grown through a series of mergers and acquisitions of firms that focused on different components and rarely collaborated with one another, they need to find ways to coordinate knowledge resources among these units to deliver seamless experience. As these communities and units still operate under the auspices of corporate headquarters, the social translations among these actors are based on dialectical connections. Furthermore, the innovation network is populated with a heterogeneous base of installed knowledge resources including various forms of digital technologies. Therefore, the cognitive translation is likely to be highly problematic.

### 3.4 Type D: Doubly Distributed Innovation Network

The most complex form of innovation network is one where organizational control is distributed and knowledge resources are highly heterogeneous. Many of the project-based teams operate in these types of innovation networks. For example, in a typical construction project in the AEC industry, there are multiple small firms that belong to different trades and use different knowledge resources and unique tools. They each follow their own unique logic and trajectory of innovations. Yet, these trajectories are often interlaced with one another influencing each other’s future. Similar types of innovation networks can be found in a highly volatile new technology markets such as mobile services [50]. In that market, many previously unconnected actors (phone operators, software companies, content providers, hardware device manufacturers, etc) bring their own perspectives and technological frames in order establish new services and build up new institutional arrangements [23]. Scientific communities often form this type of innovation networks [20]. The key challenge here is to mobilize various innovators who have different, and often conflicting, interests. The knowledge resources are invested and contested [13]. A form of collective action is required in order to successfully mobilize actors and resources [23]. In this type, both cognitive and social translations are highly problematic. This type of network is populated with highly heterogeneous and contested sets of technology tools. The cognitive translation in this type of innovation network is likely to be more pronounced than in the case of Type C as it is amplified by the existence of equally problematic social translations. The social translations are highly challenging, as they are most likely to be based on dialogical connections. The social translations will remain dialogical until a dominant technological frame emerges and is legitimized. Even after an emergence of new technology frame, it is likely that the connections between actors will remain dialogical as each actor pursues their unique perspectives and identity.

## 4.0 Discussion

In this paper, we have proposed a taxonomic framework of innovation networks. Innovation networks form socio-technical systems that operate in a distributed cognitive space. The generative processes in these networks involve both cognitive and social translations. At the same time, the rapid developments of digital technologies have reduced communication costs and allow integration of previously unconnected activities and artifacts due to digital convergence. The two forces of digitization – reduction in communication cost and digital convergence – stretch the innovation networks in two dimensions. On one hand, we see an increasing distribution of control and coordination among actors in innovation networks. On the other hand, we see an increasing heterogeneity in knowledge resources that are mobilized in a network. These two dimensions allow us to conceptualize four types of innovation networks that involve different conditions of the use of digital technologies. Below, we will discuss the implications of the proposed framework for the evolution and design of information infrastructures, future innovation research drawing on network analyses, and the new interlacing of ontology and epistemology of innovations.

### 4.1 Implications for Digital Information Infrastructure

In contemporary organizations, information infrastructure plays increasingly vital role in creating and sustaining innovation networks. It acts both as a constraint and an enabler. In each of the four types of networks the nature and control of the information infrastructure is different which affects its evolution. Therefore, changes from one type of configuration to another is simulatenously a technological and a control and coordination challenge. Another key challenge is the need for maintaining flexibility and stability in the design and evolution of these networks.

Information infrastructures need to also mediate both cognitive and social translations though they have different set of requirements for their support. In the case of cognitive translations, the infrastructure needs to provide a flexible set of capabilities to accommodate the diverse set of representational models while innovators attempt to translate one cognitive model to another. This is especially challenging in types C and D. Innovators want to explore alternative, heterogeneous representations and they need to mobilize simultaneously multiple representations to explore different design and innovation options. We label this requirement as *representational flexibility*.

At the same time, representations need to retain the semantic coherency through (meta) model-based control. For example, in the AEC industry, while architects translate 2D drawings into 3D digital model, or vice versa, the parametric relationships among elements of the building get often lost. The translated representations simply conserve the shape of the other model, without retaining any of the semantics of the objects involved. New breeds of digital repositories, through their rule-based and model-based control, allow heterogeneous models to retain increasingly coherence and allow "intelligently" map one object world to another [4]. That is, if a building surface needs to be constructed with concrete having a certain strength and cost, the family of models retains these properties throughout the design. We label this requirement as *semantic coherence*. The semantic coherence means that representations that share the same semantic core can be easily organized and manipulated as a group. This challenge again is important in types C and D where one needs heterogeneity, but at the same time the solutions needs to be organized on the common ground.

Finally, cognitive translation process is fundamentally non-linear. This implies that various model instances need to be traced during the design to observe where views converge or diverge. Therefore, it is also important to be able to trace "through" the innovation processes *during* and *into* the innovation network. We label this requirement as *temporal and spatial traceability.*

For social translations, information infrastructure needs to act as knowledge broker that organize around structural holes. This is in particular needed in types B and D. Hargadon and Sutton [22] observe that in order to support innovation processes, knowledge brokering needs to be combined with organizational memory that maintains a common ground for knowledge sharing and helps find who knows what. Human knowledge brokers are known to connect to unconnected communities and radically reduce the distance among actors, thus creating a small world condition [48]. Information infrastructure can help amplify such processes in innovation networks when they grow and become more heterogeneous.

In the case of complementary connections, information infrastructures need be presented as intermediating nodes that connect distant and heterogeneous actors. In the case of dialectic and dialogical connections information infrastructure must permit partisan representations among innovators in their negotiations at the boundary. In the case of dialectic connections, the information infrastructure needs to adopt pragmatic boundary objects that help transform the knowledge to forms and situations that allow different parties to seek synthesis [13]. In the case of dialogical connections, on the other hand, information infrastructures need to become linguistic "calibrators" that supports ongoing discourse between actors by mapping vocabularies, offering discursive context to maintain common ground.

## 4.2 Implications for Innovation Research with a Network Perspective

Four types of innovation networks organized and built around digital technologies present new research challenges. So far our research has mainly focused on types A and C which clearly are the more simple forms of innovation context. To better understand the differences between different innovation contexts and to articulate conditions under which organizations can move from one innovation network to another, we need new theorizing. In particular, we need to formulate new constructs, operationalizations and measurements that help us study innovation dynamics.

Social network analyses have been already embraced as a way going forward by many innovation scholars in understanding innovation dynamics. However, our analysis of four types of innovation networks raises further questions how far we have or can move with theoretical constructs and methodological tools that operate only at the "social" plane.. Established network models under-theorize the role and nature of digital information infrastructures as connection and translation "platforms". As noted above, digital tools must be conceptualized simultaneously as nodes and connections. Some virtual team research has used network analyses, to reveal and understand the role of computer-mediated connections in building social networks [2]. At the same time there is virtually no work theorizing about digital technologies as nodes and translators. This requires a richer and more nuanced analysis of IT artifacts and their capabilities and how they connect to build innovation networks. At the same time, one cannot rush blindly to add digital technologies just as "additional" nodes and connections in the traditional "social" network models. Different IT artifacts have different capabilities and roles as nodes and connections that need to be carefully distinguished. We need to recognize that there are characteristics that human actors and technology artifacts do not share. As nodes, technology artifacts have capabilities that surpass or replace the capabilities of the human actors (e.g. computational capability). At the same, reflexivity in human agency is something that technology artifacts do not possess. Overall, we invite more theoretical and empirical works that examine the behaviors and structures of technology artifacts in different types of networks in order to better understand how they shape networks, by exploring their topologies and the behaviors of innovation networks.

Traditional network models deal also with power and conflict in a limited way. This needs to be expanded, in particular, if we want to study Type B and Type D innovation networks. Radically departing from the received idea of power that draws upon the hierarchical position and the idea of access to resources – a capability of one agent over another to make him follow the will of another – needs to be re-conceptualized in the context of distributed and autonomous agents that consist of both humans and digital artifacts. Theories explaining collective action or Focault's work on disciplinary power based in visibility and internalization of the observations [18] offer here a useful starting point.

The very notion of innovation networks suggests that the organization of the network – who is in the network and how they interrelate – has a lot to do with the content of innovation network – what the actors think they are about to innovate. Thus the "ontology' of the innovation cannot be separated from its epistemology: what actors innovate mirrors who is enrolled in the network what he knows.

Finally, the idea of alternative categories of innovation networks challenges current ways of measuring innovation with a single construct. When innovation is viewed to be distributed and emergent, it is not clear where, when and how one can measure it and its progression. It is equally challenging when one compares different innovation networks. Accordingly, we need some types of innovation indices and categories of the network structures and their behaviors that reflect critical properties of the distributed and heterogeneous innovation. These indices should capture not only the epistemology of innovations, but also their ontology.

## 5.0 Conclusion

As various forms of digital technology become an essential part of our everyday practices, it is critical to examine how increased digitization affects the way organizations in groups change and innovate. Our paper makes some steps in this direction by proposing a taxonomic framework of innovation networks. Future empirical work needs to expand the proposed theoretical model with careful analyses of the dynamics and behaviors of different innovation networks, and how these formations shape the emergence of new processes, services and products in all walks of life.

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