# Knowledge and innovation in the agrifood supply chain: Old metaphors and new research directions

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**Abstract:** *Research dedicated to illuminating the relationship between knowledge and innovation within agrifood supply chains (ASCs) – although insightful and informative – is marked by conceptual and methodological issues that restrict our ability to understand the ways knowledge affects innovation and vice versa. In this work, adopting a systems approach to ASCs and synthesizing literature from different fields of study, we discuss the metaphors that guide research in this area, and we propose an alternative conceptualization of ASCs. In our view, ASCs represent open, dynamic systems, which base their value-generating capacity on the relational integration of knowledge among actors. This procedure of knowledge integration provides impetus to innovation, thus sustaining the value creation process across and beyond the system. This line of thinking generates a new set of questions and opens up some new research directions.*

***Keywords:*** *innovation, knowledge, supply chain, value, systems approach, agrifood systems*

## Introduction

The question “how to effectively deal with innovation?” is not a new one and, certainly, is quite complex to be resolved. Already from the early 1960s, scientists began to develop interest on the ways innovation in the agrifood supply chain (ASC) can be intensified (Griliches, 1960; Ruttan, 1960). In the relevant literature it is more than well-documented that knowledge plays a pivotal role in innovation process, facilitating innovation adoption, expediting adaptation to innovation, and strengthening innovation capacity. Nevertheless, as Morgan and Murdoch (2000) have showed, structural and functional attributes of ASCs catalyze the ways knowledge evolves within each chain. In this work, responding to the recent call for more intense research on the interrelation between knowledge and innovation in the agrifood sector (Meijer et al., 2015) we aim to highlight some important issues associated with current research approaches and to propose some new research directions in the field.

The conceptualization of ASCs used in our study rests on three basic maxims. First, ASCs are not just coalitions of actors but they have the qualities of open systems (Pigford et al., 2017). Indeed, ASCs are characterized by all the five systems principles detailed by Gharajedaghi (2011): ASCs are open to various external – political, economic, social, geophysical, environmental – influences (openness), they operate under a – more or less – specific purpose (purposefulness), they are composed from multiple wholes (multidimensionality), their performance depends more on the quality of the interactions among actors rather than on the quality of these actors (emergent property), and they are

characterized by a high degree of uncertainty in that every intentionally generated action can lead to an opposite to the desired outcome (counterintuitive behavior). Second, ASCs are characterized by a high degree of complexity which hampers both innovation process and knowledge production (Röling, 1992). The high degree of interdependence among actors (Li et al., 2009) and the lack of control over the external market environment (Serdarasan, 2013) give further rise to this complexity. As Surana et al. (2005) mention, oftentimes the intricacy of supply chains is comparable to that of biological systems. Third, adopting the Service-Dominant Logic (Vargo and Lusch, 2004), we built our work on the idea that the core activity of an ASC is not the moving of a good but the exchange of service among interrelated actors. As Vargo and Lusch (2014) put it, the actors in such a system integrate applied knowledge, skills and expertise to produce value. In this vein, even farmers are service providers, since they use their competencies to produce primary products. Under this prism, every ASC constitutes a dynamic system which is based on a mutual exchange of competences (Vargo and Lusch, 2016) through which it produces value (Lusch and Nambisan, 2015).

Drawing upon the framework provided by these three maxims, and following a systems thinking lens, we focus on three metaphors that guided past research in the area, and we propose some alternative views of the intriguing interrelation between knowledge and innovation. As we explain in the following sections, the diffusion metaphor, the metaphor of chain, and the metaphor of value flow, might obscure some important qualities of ASCs, thus restricting our ability to identify the ways knowledge evolves through innovation, amplifying in parallel the innovation potential of any ASC. Using as a conceptual basis literature from the field of supply chain management, and applying insights from organizational learning, network science, sociology, agricultural extension, business management, and service marketing, we attempt to integrate different lines of thinking into a new perspective which opens-up new research windows.

## Innovation process: A story of diffusion or a drawing of co-evolution?

### *The diffusion metaphor*

Questions concerning knowledge transfer and innovation adoption have been characterized by the changing roles of agricultural activity. Therefore, in order to comprehend the evolution of knowledge systems it is necessary to combine political action and agricultural sociotechnical regime (Geels and Schot, 2007). After World War II, until the end of 1970s the main target of the agricultural policies was strictly linked to food security. This has brought about direct tools of agricultural policy oriented towards agricultural productivity. Consequently, fields of knowledge were essentially scientific and were identified with the best productive techniques. Against this background, the role of extension systems was related to technology transfer, through the adoption of supply-driven or top-down linear models (Godin, 2006). Within these models, the innovation process is drawn on mechanisms of progressive adoption of the new knowledge, which discriminates different types of actors. According to Rogers (1962) the innovation process has a social nature, since it includes a stage of diffusion from the innovators – those actors who are characterized by a high degree of "venturesomeness" (p. 248) leading them to take risky decisions – to early adopters, before the innovation being adopted by the (early and late) majority of stakeholders and finally being accepted by laggards. In this approach of innovation transfer, models of governance are based on the central role of the public sector, which absorbs the role of planning, coordinating, sometimes realizing and, above all, funding agricultural innovation, with the purpose of distributing knowledge and fostering adoption.

The idea of innovation behind the Rogers' model cannot be taken for granted in the new paradigm of multifunctional agriculture, where new societal and environmental instances are at stake. Within this paradigm relevant questions concern, firstly, the ways knowledge and

innovation stimulate and support transition towards multifunctionality and, secondly, the notion of innovation that should be privileged (Knickel et al., 2009). Therefore, a deep change in the analytical perspective is required, aiming at removing the black box perspective about innovation and the linear paths of innovation diffusion under the hypothesis of "epidemic" dissemination of information, knowledge and, thus, innovation (Hagerstrand, 1965).

The main limitation of supply-side theories is that they neglect the various socio-territorial and institutional contexts. Recent trends in institutional and evolutionary approaches have brought about a growing resort to social analysis of human behaviors also in the field of innovation diffusion. In the new vision, social interactions may stimulate diffusion of information, knowledge and innovation: consequently, comprehension of social mechanisms regulating ways of learning is fundamental to define innovation policies in a local system. To do that it is necessary to espouse an extended concept of technology, including "hardware" (capital, transaction costs, etc.) and social mechanisms too, or "software," that permit diffusion at local level (Klerkx and Leeuwis, 2009).

### *Knowledge: A driver of diversity or a vehicle for transformation?*

The diffusion metaphor leads to a divisive view of innovation. In such a consideration, the wealthier actors have better access to innovation spaces, whereas actors who lack economic resources are placed at the far right of the well-known innovation adoption curve (Rogers, 1995). Hence, innovation process is a mechanism that creates diversity within the system. More importantly, knowledge is produced (through innovation implementation) and then propagated across a sector following a similar pattern of diffusion. Consequently, innovators and early adopters can develop a greater innovation potential, since they have the ability to attain higher profits not only in financial terms but also in the form of knowledge and competencies. Moreover, such a contextualization of innovation tends to overestimate both the systems nature and the complexity of ASCs, given that innovation is viewed as a process circumscribed within the limits of a single sector. In other words, each node of the ASC (farmers, market entities, consumers) develops a separate sphere of knowledge.

In order to contextualize the problematic of knowledge transfer in rural areas, different trajectories of rural development need to be taken into account under the affirmation of multifunctional agriculture within the European agricultural model (van der Ploeg, 2010). Recent rural development policies prioritize the knowledge production as a key means to boost innovation in the agrifood sector. This priority is strictly associated with territorialization of rural policies, as the output of diversified and heterogeneous mechanisms of rural development (Berriet-Solliec et al., 2009). As it is pointed out by Klerkx et al. (2012), transition process towards sustainable and multifunctional agriculture may originate changes at different levels in agricultural systems and within the food value chain, being them tied with different types of innovation: technological, social and institutional (Klerkx et al., 2012; Klerkx and Materia, 2015).

Accordingly, knowledge dynamics are functional to either different strategies of rural development and rural context (urban vs. rural) or types of innovation. In this context, cognitive needs in rural areas and the collective, "multi-local" knowledge become central elements of analysis, in order to stimulate innovation in each rural context (Crevoisier, 2014). Against this background, a problem of coherence in knowledge creation and anchoring (Crevoisier, 2016) to boost rural innovation emerges. Territorial anchoring of pertinent knowledge is drawn on a growing interdependence of even more heterogeneous local actors. Therefore, due to the strong interconnections between types of innovation and required changes at different levels of the agrifood chains, interrelationships between various actors operating at each level becomes a relevant field of analysis.

Recent literature provides a fertile body of research based on systems approaches (Klerkx et al., 2012) viewing innovation as a "co-evolutionary process, marked by simultaneous and

interconnected changes in technology, markets and value chains, land tenure systems, and input, certification and quality control arrangements" (Adjei-Nsiah and Klerkx, 2016). Set against this context, agricultural innovation system is a commonly used framework of analysis, conceiving innovation as the output of interaction and social learning among a diversified set of actors (Klerkx et al., 2010). More recently, innovation platforms have been used as a vehicle for boosting local innovation both in developed and in developing countries, through the creation of learning spaces where heterogeneous actors interact and share knowledge with the purpose of facilitating innovation (Drior et al., 2016; Adjei-Nsiah, Klerkx, 2016). As Swaans et al. (2014, 240) posit "in recent years, innovation platforms (IPs) – spaces which allow individuals and organizations to come together to address issues of mutual concern and interest – have been promoted as a mechanism to stimulate inclusive innovation in the context of agricultural value chains." At a political level, generation of innovation platforms is strongly encouraged, for example through rural development policies for the period 2014-2020 in European Union, with the purpose of stimulating operational groups.

## Of lines and spaces

### *The chain metaphor and the assumption of linearity*

In a conventional conceptualization of ASCs, farmers, manufacturers, wholesalers, distributors, and – apparently – consumers are linked to form a chain of actors. In this view, ASCs are conceived as linear configurations in which the actors represent separate nodes linked by one-way arrows moving from the producer to the final consumer. Indeed, some of the most influential scholars in the field of supply chain management defined supply chains as sets of actors which align to pass products forward (Tan, 2001; La Londe and Masters, 1994). Nevertheless, this conception is rather simplistic as other actors are also involved in the most supply schemes: suppliers of the immediate supplier, intermediate customers, and a wide set of organizations, institutions or communities might be involved in the various upstream and downstream flows of goods, services, resources and capital (Mentzer et al, 2001). In addition, the operation of any supply chain is heavily affected by a wide array of external factors, such as the economic growth (or recession), the globalization of markets, the intensity of competition, and the development of technological infrastructures (Aelker et al., 2013; Blecker et al., 2005).

In this vein, ASCs are compelling systems, which instead of resembling a pipeline, have the features and the qualities of a constellation of actors. In these arrangements, the involved actors mobilize and combine knowledge and competencies to mutually produce value (Normann and Ramírez, 1993). Dynamic dyadic and multi-party synergies and relationships are formed and reshaped during the operation of such a constellation (Giannakis and Croom, 2004), facilitating knowledge and information exchange within an ASC (Neutzling et al, 2018; Hult et al., 2007). Importantly, these webs of actors do not operate in isolation from the wider galaxy in which social and economic activities take place. Hence, both knowledge and innovation can also penetrate an ASC system through an osmotic mechanism.

### *The "spacetime" of agrifood supply chains*

Shifting the focus from linear to multi-dimensional approaches permits us to challenge traditional assumptions on the ways innovation affects knowledge creation within the ASC and vice versa. In our view, ASCs represent systems of actors connected through value creating ties. For instance, consider a rice supply chain. In a conventional conceptualization, the chain consists of rice producers, processors, wholesalers, retailers and consumers, as well as from the input providers (Wong et al., 2010). At first glance, this portrayal seems to

satisfactorily outline the chain. Nevertheless, suppliers of raw components (e.g., packaging materials), energy providers, legal service providers, and firms offering supporting or repair services comprise an extended sphere, which interacts – directly or indirectly – with all the nodes of the chain (Sarkis et al., 2011; Lambert et al., 1998). In addition, credit institutions, research organizations, public agencies and non-governmental organizations, or even informal publics (such as advocacy groups, activist organizations, and scientific bodies) exert considerable influence over the ASC.

In order to integrate these peripheral actors into the ASC, it is important to plot a new, more detailed viewpoint of ASCs. Supply chain literature postulates that most of the above mentioned entities bond to at least three other actors (Min and Zhou, 2002), indicating that ASCs have a three-dimensional structure. Hence, the visualization of ASCs as "molecular" wholes can provide a more appropriate jumping-off point for understanding how – and why – innovation reshapes interactions within the chain, intermediating in parallel the co-evolution of what Vargo and Lusch (2004) term "operant resources," which include core competences such as knowledge and skills. As Figure 1 illustrates, ASCs can be better conceived by adopting a core-periphery conceptualization. Such an approach can effectively depict the interconnections among the different nodes involved in complex networks (Borgatti and Everett, 2000).

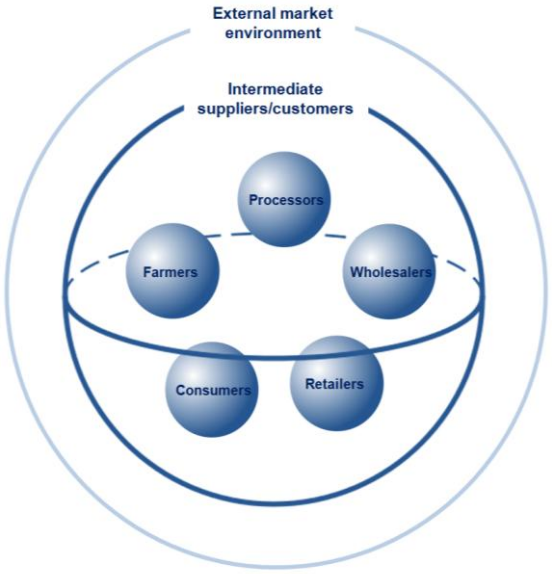


**Figure 1.** A simple molecular model for ASCs

In our model, farmers, processors, wholesalers, retailers and consumers form a relatively cohesive core, in that they are interconnected and – to a great extent – mutually dependent. On the outskirts of this core there is a less cohesive set of actors, who are tied to the core nodes of the model but they are loosely interconnected to each other. This corpus of actors includes all the entities which supply the core actors with resources, information, raw materials or and/or buy intermediate products, by-products or residuals. At a third level, this sphere of intermediate suppliers and/or customers is surrounded by a cloud of actors who constitute what we term "external market environment" (banks, research institutes, policy organizations, governmental agencies, etc.). Although the actors located in the nucleus of the model have limited ability to exert control over the external market environment, these external nodes largely determine the expanse within which an ASC operates. However, the operation of an ASC is also characterized by a lack of periodicity (Wilding, 1998), which compromises our ability to predict the changes an innovation can induce to the chain.

Moreover, as Serdarasan (2013) explains, a series of forces increase the time uncertainty under which supply chains operate. In that sense, time is a pivotal extra dimension in the abovementioned three-dimensional structure.

Nevertheless, the visualization of ASCs presented in Figure 1 remains oversimplified. Indeed, in real market environments, every ASC has – more or less obvious – linkages with other chains or networks (Cooper et al., 1997), since, as Lambert and Cooper (2000) note, it is somewhat rare for the intermediate actors to participate in only one chain. Hence, some nodes of the chain can operate as cutsets (Moody and White, 2003), i.e. as nodes connecting different chains into a new system. For instance, turning back to the rice supply chain example, rice processors might also be involved in the grass pea supply chain, assembling the two supply chains into a new system (Figure 2).

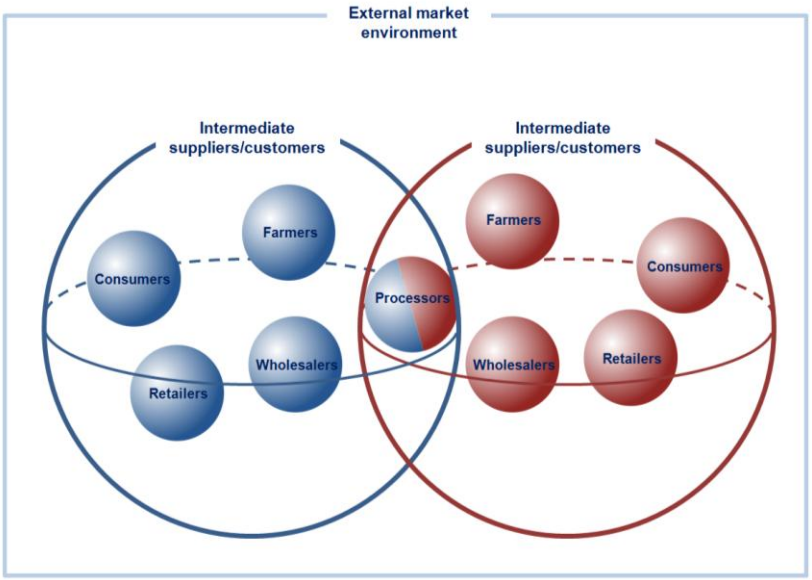


**Figure 2.** The spacetime of a simple agrifood supply system

### *Knowledge and innovation within, across, and beyond the agrifood supply chain*

In the literature it is well documented that within any supply chain, different patterns of knowledge creation (Malhotra et al., 2005), transfer (Modi and Mabert, 2007) and sharing (Dyer and Nobeoka, 2002) exist. According to Samuel et al. (2011), "learning-by-doing" processes are often used by individual actors and their partners to construct new knowledge. This way, independent actors can develop – through a process of acting and reflecting – specific skills, which in turn produce a knowledge flow towards the other members of the chain, thus paving the way for innovation (Lazzarini et al., 2001). Nevertheless, evidence from the field of organizational learning suggests that this type of knowledge might or might not be relevant to other actors (Schulz, 2001). For example, the process of innovation adoption by farmers can create a new pool of exploration-based knowledge, which however cannot always be applied in the other nodes of an ASC. This "uncertain relevance" of new, inference-based knowledge generates the need for targeted actions aimed at supporting knowledge integration across the ASC. In other words, to support innovation processes within an ASC, it is essential to externally synchronize knowledge construction and sharing mechanisms (Mustak, 2014).

On the other hand, the degree to which knowledge is shared among different actors depends on the type of interactivity (Van Wijk et al., 2008), the balance of power within the chain (Wu and Chiu, 2018; Muthusamy and White, 2005), and the levels of inter-actor trust (Liu et al.,

2017). Viewing ASCs as linear layouts reduces our opportunities to capture in full the distribution of power, trust, and knowledge production, therefore eliminating our ability to depict the ways knowledge co-evolves and is spread across the chain. According to our alternative view of ASCs as dynamic systems, each actor is tied to all other involved nodes, exchanging not only economic but also social elements, which deserve more research attention by scholars (Griffith et al., 2006). The incorporation of Emerson's Social Exchange Theory (Emerson, 1976) into research on ASCs can open up new and exciting research avenues, shedding light on the ways knowledge exchange and innovation processes can be reinforced. Such an approach could help practitioners to identify appropriate strategies to optimize reciprocity within ASCs (Cropanzano and Mitchell, 2005; Blau, 1964), thus facilitating the exchange of the knowledge generated after the adoption of an innovation across the chain.

Moreover, the interconnectedness between ASCs generates some new riddles. Notably, the introduction of an innovation in an ASC has also important impacts in other supply chains, since it produces several types of externalities that expand beyond a single supply chain. In supporting this argument, Kogan et al. (2017) discovered that innovation process is accompanied by a resource allocation not only within but also between different sectors. The changes which emerge as the aftermath of the redistribution of resources can generate important unpredictable fluctuations, leading to bullwhip-like effects. In other words, the outcomes of these changes can increase in volume as one moves forward from the starting point of the change, a phenomenon also evident in the demand order variability within supply chains (Lee et al., 1997; Forrester, 1958).

To avoid these potential perils of innovation, the development of innovation-specific knowledge is essential. However, as Woo and Katok (2006) point out, equally important is the process of communicating and sharing this knowledge between adjusted nodes. It is the quality of communication process which permits the combination of different pieces of knowledge into a meaningful puzzle (Fisher, 2001), as well as the ability of ASC's nodes to absorb external knowledge (Giuliani and Bell, 2005) that affect the degree to which supply chains are adapted to the new status quo that innovation creates. Nonetheless, the factors that strengthen inter-actor communication, and improve knowledge absorbing capacity within ASCs, have received limited research attention to date.

## Reframing the value of innovation

### *The metaphor of value flow*

Traditionally, supply chain literature considers value as an asset that is to be delivered to the consumer (Cristopher, 2016; Flint et al., 2008). Nevertheless, theorists and researchers in the field have not reached a common agreement on the nature of value. For example, Klibi et al. (2010) measured value in financial terms, whereas others (Ketchen and Hult, 2007; Cox, 1999) associated value with indices of supply chain performance. A common denominator of these approaches is the use of market-based thinking to frame the issue of value. In such a theorizing, value is created by one actor and then is transferred to the subsequent nodes of the supply chain, thereby producing a value stream throughout the chain. From this outlook, each actor produces and then conveys value in the form of tangible products or services (storage, distribution, etc.) to an immediate customer, receiving in turn a corresponding payment. Hence, value emanates through the exchange of products (or services) and money.

In line with this reasoning, a widely accepted assumption is that every innovation has a value which by default is transmitted from the adopter to the other nodes of the chain. According to this viewpoint, actors' knowledge facilitates the exchange of value between adjusted nodes. However, this conceptualization of value is rather flawed for a couple of reasons. First – especially in the case of ASCs – the term "value" has different meanings for the actors

involved (Manning, 2015), whereas it also includes an important social dimension (Ericksen, 2008). Second, as Vargo and Lusch (2008) argue, the "value-in-exchange" approach tends to overestimate the active role of the interrelated actors in the process of value creation. On the contrary, a shift of our attention from the parts of the chain to the whole system can provide the ground for an alternative conceptualization of value. Indeed, by emphasizing inter-actor relationships, the value is conceived as an interactional outcome which is produced mutually and reciprocally by all the actors involved in the system (Vargo and Lusch, 2010).

### *Zooming out: Shifting focus from dyadic relationships to value-creating constellations*

Conventional approaches to innovation emphasize the dual relationships between adjusted chain nodes, attributing to value a consumable nature. However, although innovation process has always as a topmost aim to create new forms of value (Arlbjørn et al., 2011), a system's value-generating capacity depends on the flexibility of the involved actors (Koskela-Huotari et al., 2016), the existing coordination mechanisms (Beirão et al., 2017), the reciprocity biases within the system (Frow et al., 2014), and the degree to which innovation process is open to the all interconnected actors (Lusch, 2011). Hence, widening our lens to include all the tied actors in the process of value creation allows us to precisely capture the interrelatedness between knowledge and innovation in the ASCs. From a service ecosystems perspective (Vargo and Lusch, 2011), it is the actors' knowledge that puts the basis of innovation. In this sense, innovation process can be viewed as the "combinational evolution of new, useful knowledge" (Vargo et al., 2015). Under this prism, value is always multidimensional and emergent (Vargo et al., 2017).

From this standpoint, rather than being cumulative, knowledge co-evolves through a dynamic process, within social contexts formed by actors and institutional arrangements (Akaka et al., 2012). The complexity of this networked nature of value – also evident in recent works adopting an innovation systems perspective of ASCs (Botha et al., 2017; Osei-Amponsah et al., 2017) – generates the need to consider both knowledge and innovation in a more contemplative fashion and calls for more interdisciplinary research designs aimed at answering a series of targeted questions. First, how the interdependencies among actors can be boosted in order to sustain ASC's innovation capacity through the co-evolution of context specific knowledge? Second, which are the appropriate intermediation schemes that can facilitate the production of this knowledge? Third, how policy and research organizations can support knowledge integration within – and between – ASCs? As Vargo and Akaka (2012) note, this integration puts the basis for the iterative creation of value, this way enhancing the wealth of any ASC.

## Conclusions

This paper has to be considered as a first step towards a new theoretical framework aiming at exploring the puzzle of knowledge creation, diffusion and innovation adoption within ASCs. Starting from the removal of linear transmission hypothesis the article puts forward more heterodox perspectives of knowledge transfer, which posit that the higher/lower permeability of ASCs towards innovation depends on multiple dimensions that need to be taken into account. Against this background the ASC can be viewed as a "permeable" system able to absorb knowledge, through interactive processes among actors. Moreover, permeability of ASCs implies to take into account the type of knowledge that fits best for each ASC, by stimulating the debate around pertinent knowledge adoption. In this context, new roles designed for ASCs in the modern vision of multifunctional agriculture make these processes more complex and let cumulative knowledge to give the way to "composite knowledge dynamics" (Crevoisier and Jeannerat, 2009). These dynamics are characterized by mechanisms of co-evolution, where each node of the chain may provide the other actors in

the chain with new value in the form of knowledge. Consequently, a potential for a portfolio of value emerges in these processes that need to be further explored from an empirical point of view.

The analysis of social mechanisms of technical innovation transmission provides insights for planning and implementation of development policies. The wider meaning of technology adopted here, which include not only the "hardware" (e.g. capital, equipment, transactions costs, etc.) but also the "software" structure (e.g. customs, habits, practices, etc.), brings about a new perspective in the policy-making for innovation aiming at catching the multiple dimensions interfering in these mechanisms.

To conclude, in this work we argue that ASCs should be thought of as dynamic, open systems, operating under the aim of producing value. Innovation, emerging as the combinational evolution of competences and knowledge, leads to some new patterns of resource integration among interrelated actors, thus sustaining the value-generating capacity of such systems.

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