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The costs of collaborative innovation

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Abstract
Collaborations between actors from different sectors (governments, firms, nonprofit organizations, universities, and other societal groups) have been promoted or mandated with increasing frequency to spur more innovative activities. This article argues that there is an essential gap in evaluating the issues of these collaborative arrangements on innovation and a need to theorize the costs of these arrangements systematically. This article identifies three implicit assumptions in current research that prevent a sound analysis of the costs of collaborative innovation and advances a new cost theory based on the integration of studies from several research fields and explanations provided by three main economic theories: transaction cost economics, game theory, and the knowledge-based view. In particular, four overarching factors are posited to impact the effectiveness of collaboration for innovation: *governance* (the number of collaborators and the hierarchical relationships among them); *compactness* (the degree of relationship formality that binds collaborators together); *reliability* (the quality of the relationships); and *institutionalization* (the extent to which the relationships have been pre-established by practice). We discuss the importance of leveraging these factors to determine an optimal governance structure that allows collaborating actors to minimize transaction, cooperation, and knowledge costs, and to reward participants proportionally to the cost they bear, in order to foster conditions of reciprocity, fair rates of exchange, and distributive justice.

Keywords Collaborative innovation · Cross-sectoral collaboration · Transaction cost economics · Game theory · Knowledge-based view · Governance

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1 Introduction

Innovation is increasingly pursued through the collaboration of a vast array of stakeholders, including private sector firms, public sector organizations (such as government agencies, state administrations, and local governments), and nonprofit organizations (the third sector), along with groups and individuals from the civil society (Barrutia & Echebarria, 2019; Moore & Hartley, 2008; Sørensen & Torfing, 2011) and from universities and research institutions (Demircioglu & Audretsch, 2019; Miller, 2016; Walsh et al., 2016). This type of collaborative innovation, based on cross-sectoral collaboration, is becoming increasingly important in norm and practice, since it is expected to be necessary to address contemporary grand challenges and wicked problems (e.g., Agranoff & McGuire, 2001; Demircioglu & Vivona, 2021; Gazley, 2014; McGuire, 2006; Waardenburg et al., 2020). In addition, current research argues and finds evidence that cross-sectoral collaborations lead to more innovation (Barrutia & Echebarria, 2019; Demircioglu & Audretsch, 2020; Torfing & Triantafillou, 2016). Hence, cross-sectoral collaboration has become a "key innovation strategy" for innovation (Hartley et al., 2013, p. 826), and organizations aim to promote more collaborative activities with an extended range of partners.

Underlying the theoretical positioning of this strategy stands the assumption that collaboration has a positive impact on organizational innovativeness, which, in practice, results in the proposition that collaboration is often "perceived as a value in itself" and as an "objective to be met" (Voorberg et al., 2015, p. 15). Nevertheless, collaboration for the sake of collaborating may be highly detrimental for organizations: collaboration is costly, as it requires greater use of resources of money, time, and effort (Torugsa & Arundel, 2016; Wegrich, 2019), and, additionally, there may be operational, technological, performance, and legal barriers to effective collaboration (Agranoff & McGuire, 2004; McGuire & Agranoff, 2011).

This gap is unfortunate because, as Audretsch and Belitski (2019, p. 22) argue, "research is needed on innovation collaboration costs", and, although some studies exist regarding the barriers or costs of collaborative arrangements (e.g., Cummings & Kiseler, 2007; Nooteboom, 2008; Terjesen & Patel, 2017; Torugsa & Arundel, 2016; Van Knippenberg et al., 2004), these studies do not comprehensively discuss these costs.

By showing the contingencies under which collaboration is preferred, some scholarly efforts have aimed to address this gap. For instance, Felin and Zenger (2013) examine how a specific governance form (i.e., closed vs. open and collaborative forms) can be chosen by private enterprises on the basis of the attributes of the innovation problem. Hartley et al. (2013) compare innovation strategies for public sector organizations, and they illustrate the conditions that make collaborative innovation superior to "in-house" innovation (i.e. New Public Management market-driven innovation and neo-Weberian bureaucratic innovation), while O'Toole (1997) points out the importance of understanding and evaluating the cost of interagency collaboration, as collaboration may be a significant cost to governments. Similarly, Fallis (2006) compares how analyses of collaboration systematically differ across scholars in different fields (e.g., science vs. philosophy), illustrating the characteristics of scholarly research that make collaboration successful.

While these studies provide relevant insights, they are deeply rooted in their own sectoral traditions. Private sector studies (e.g., Audretsch & Belitski, 2019; Terjesen & Patel, 2017) focus on commercial, market, industrial, and technological innovations where the primary aim is to create value through increased profits or market share, while public and third sector studies (i.e., nonprofit organizations) focus on public and social innovation to

create public and social value (e.g., increased legitimacy and equity) (Torfing & Triantafillou, 2016). We intend to overcome this limitation by taking a sector-neutral perspective on innovation, which is more suitable to the analysis of cross-sectoral collaborations. Moreover, while most studies explore the conditions favoring collaboration (e.g., Moore & Hartley, 2008; Sørensen & Torfing, 2011), there is also a considerable gap in the systematic analysis of the specific costs of collaborative innovation, which is required in order to reject or confirm collaborative approaches to innovation on the grounds of cost–benefit analyses (Bommert, 2010). This is particularly important in light of recent works suggesting that innovation and collaboration exhibit diminishing marginal returns (Audretsch & Belitski, 2020; Denicolai et al., 2016; Kobarg et al., 2019); in other words, as Torfing (2019, p. 5) states, "[t]he Achilles heel of collaborative innovation is the inherent tension between collaboration and innovation".

To address this gap, we employ three theoretical perspectives, namely transaction cost economics, game theory, and knowledge-based view, to integrate studies from several research fields, and we develop a new cost theory which systematizes said insights according to four main factors: *governance* (the number of collaborators and the hierarchical relationships among them); *compactness* (the degree of relationship formality that binds collaborators together); *reliability* (the quality of the relationships); and *institutionalization* (the extent to which the relationships have been pre-established by practice). In doing so, this article focuses on cross-sectoral collaborative innovation. Undeniably, collaborative innovation also takes place within sectors (i.e., intra-sectoral collaborative innovation); the reader should be mindful that intra-sectoral collaborative innovation may, in some cases, simply exhibit a subset of the costs discussed here, but, in other cases, be inherently distinct, such as the case of collaboration with competitors – or coopetition (see Ritala et al., 2016). Moreover, we focus on a generic cross-sectoral collaboration model (which is explained in the next section) that is less specific than other models advanced in the literature (e.g., open innovation models, Triple and Quadruple Helix models) in order to shed light on a broader range of costs for innovation incurred by collaborative arrangements.

The remainder of the article is organized as follows. The following section presents the framework of our study and its underlying concepts in order to illustrate how collaboration is linked to innovation in the literature. Then, we investigate the reasons for the lack of rigorous cost–benefit analysis approaches regarding collaborative innovations. Building on previous research, we then advance an integrated cost theory that encompasses several phenomena related to cross-sectoral collaborative innovations. We also discuss the implications of our cost classification for the general literature on collaboration and innovation. We conclude by highlighting paths for future research.

2 Cross-sectoral collaborative innovation

2.1 Innovation and value creation

While the concept of innovation is multifaceted, subjective, and can be defined in various ways, a simple and straightforward definition states that an innovation is *something new and useful* (Mulgan, 2007; Mulgan & Albury, 2003): it comprises both the concepts of *novelty*—"something new", such as a new product, process, practice, postulation, or policy—and of utility, or *value creation*—"and useful", since innovation should yield results and organizations and users should be able to extract some value from them (OECD/Eurostat,

2018; Vivona et al., 2020). The latter concept is particularly interesting for the purpose of this article. The idea that innovation should be useful, and thus create some value, has been discussed widely in innovation studies: some researchers are concerned with whether the value created by the innovative process can be appropriated by the innovator (Baldwin & Henkel, 2012; Jacobides et al., 2006; Laursen & Salter, 2014; Ritala & Hurmelinna-Laukkanen, 2009) while others are more concerned with measuring the results and impact of the innovation (Arundel et al., 2019; Bloch & Bugge, 2013; Smith, 2005).

Most importantly, the concept of *value creation* is coupled with the *goal of innovation*: indeed, "innovation can have different goals and therefore can be directed to obtain different results" (Vivona et al., 2020, p. 3). Goals and objectives are profoundly different across sectors. For example, public and private sectors have different values: while the former is typically concerned with equity and enhancing citizen participation in public services, the latter focuses on the profit maximization of firms (Rainey, 2009; van der Wal et al., 2008). In other words, when the goal of an innovation is to increase profits or the market share of a firm (i.e., private sector organization), it is usually referred to as a "market innovation" or "industrial innovation" since it is directed to create *market value* (Jacobides et al., 2006). When a public sector organization seeks innovation with the goal of creating *public value* (e.g., by enhancing citizen participation), innovation is usually framed as "public sector innovation" (De Vries et al., 2016; Demircioglu, 2017; Verhoest et al., 2007). Other innovations aim at creating *social value* by reducing socio-economic vulnerabilities (i.e., "social innovation") (Murray et al., 2010; Phills et al., 2008; Van der Have & Rubalcaba, 2016).

While this conceptualization of the innovation goal is important for understanding the primary objective of an innovation, several scholars argue that innovation is multifaceted and can simultaneously create various forms of value; that is, innovation is rarely either one form or the other but more often a "blend" that creates shared value (Porter & Kramer, 2011). For instance, Emerson (2003) integrates the creation of financial and social values into a blended value proposition, stating that all firms generate returns not only in terms of better profits but also in terms of social performance. This proposition is particularly insightful to better understand cross-sectoral collaborative innovation.

2.2 Cross-sectoral dimension of collaborative innovation

Collaborative innovation has traditionally been advanced in the private sector, as the "creation of innovations across firm (and perhaps industry) boundaries through the sharing of ideas, knowledge, expertise, and opportunities" (Ketchen et al., 2007, p. 372). However, this phenomenon has been successfully applied to other sectors. For instance, Torfing (2019, p. 2) notes that "collaborative innovation offers an alternative approach to innovation that is particularly suited to the public sector. The public sector aims to produce public value, and both public and private actors (including service users and citizens) can contribute to the production of public value and are likely to be motivated to collaborate in its pursuit". Bolton and Savell (2010) describe a particular form of cross-sectoral collaboration known as "social impact bond," which blends the efforts of public, private, and third sector organizations for the delivery of innovative social programs (social value) with innovative investments that ease the monetary burden on public budgets (public value) and provide valuable financial returns to private investors (market value). Additionally, Lichtenthaler (2017) illustrates how a mobility service innovation (i.e., car-sharing) creates value, which

is shared with the manufacturer (profits) and society at large (reduction of environmental risks).

Our interest resides in studying the cross-sectoral dimension of collaborative innovation, that is, collaborative innovation which takes place across sectors and creates diverse values for the multitude of actors collaborating in the innovation process. This term also refers to the evolution of collaborations beyond the public–private sector dichotomy. Indeed, while "sector" was traditionally used to identify a distinction based on the ownership of an organization (public vs. private), this division is no longer appropriate, as other sectors have emerged.[1] For instance, from the 1970s onwards, "third sector" organizations emerged, neither owned by the state nor seeking profits but instead motivated by the goals of serving the community and by the primacy of people (and labor) over capital (Defourny, 2013; Salamon, 2002). Additionally, some scholars advance the idea of a "fourth sector," which includes organizations that simultaneously pursue the creation of social and financial value (e.g., Sabeti, 2011). As stated in the previous section, however, research suggests that such proposals fail to recognize that all organizations pursue multiple value creation (Bozeman, 2018; Emerson, 2003; Moore, 1995). In a minority of studies, the term "fourth sector" is instead used to refer to tertiary education (Benseman et al., 1996; Tobias, 1997). As education, knowledge, and learning are highly relevant to the context of innovation discourse (see e.g., Darroch, 2005; Dudau et al., 2018), we include the educational sector, along with research centres and institutions, as the "fourth sector." We also include as a "fifth sector" residual organizations and groups of individuals that pursue other distinct values in regards to innovation (e.g., generic society; social media; interest groups for environmental protection, the protection of animal rights, or the advancement and regulation of artificial intelligence).

Thus, this five-sector distinction (the *private sector*, the *public sector*, the *nonprofit sector*, the *educational sector*, and the *society at large*) is relevant to collaborative innovation; while innovation was traditionally studied primarily in terms of the private sector domain (e.g., Aghion & Howitt, 1990; Romer, 1987, 1994; Teece, 1986), substantial research has shown that the other sectors are innovative and important to the study of innovation. Research has shown the importance of innovation in the public sector (Arundel et al., 2019; Demircioglu & Audretsch, 2017) and the role played by third sector organizations in social innovation (Westley et al., 2014). The literature also reveals the impact of educational institutions on innovation systems and the role of knowledge in the innovation process (Etzkowitz & Leydesdorff, 2000; Lundvall, 1992), as well as the role of society at large in innovative user-led designs (von Hippel, 2006) or as the primary stakeholders in innovations for environmental protections (Rennings, 2000). In sum, studying all sectors

[1] In order to take a sector-neutral perspective on innovation, it is also important to grasp the concept of sector, a task which is complicated by the variety of concepts associated with the term. The Cambridge Dictionary defines sector as "one of the areas into which the economic activity of a country is divided." In this sense, economic activity is often split into employment segments such as the primary sector (i.e. jobs related to the extraction of raw materials), the secondary sector (i.e. jobs related to the transformation of raw materials into products), the tertiary sector (i.e. jobs related to service provision), and the quaternary sector (i.e. jobs related to research and development—innovation) (Pettinger, 2019). Another common (mis) use of the term is to refer, as the Collins Dictionary suggests, to industry, which is a deeper categorization of businesses based on the type of activities (e.g. the electricity industry, the tourism industry, and the manufacturing industry). The term sector is also used beyond the differentiation of businesses and can instead refer to a traditional distinction based on the ownership of an organization (public vs. private). Thus, sector refers, as in the Merriam-Webster Dictionary, to "a sociological, economic, or political subdivision of society.".

and how collaboration unfolds among them is crucial to understanding collaborative innovation and its effects.

2.3 The rationale for collaborative innovation

Collaboration is defined as "the process through which two or more actors engage in a constructive management of differences in order to define common problems and develop joint solutions based on provisional agreements that may coexist with disagreement and dissent" (Hartley, 2013, p. 826). It is different from *coordination*, which is the "orderly arrangement of group effort to provide unity of action in the pursuit of a common purpose" (Mooney, 1953, p. 86), and from *cooperation*, which is the "joint pursuit of agreed-on goal(s) in a manner corresponding to a shared understanding about contributions and payoffs" (Gulati et al., 2012, p. 537). Collaboration can be seen as merging cooperation (the commitment of actors to work towards the same end) with coordination (the organizational complexity of making actors work together effectively) (Gulati et al., 2012). When organizations collaborate, they aim to obtain more resources while achieving their goals and interests (Dias & Selan, 2022; Minson & Mueller, 2012; Tseng et al., 2020). Aiming to obtain more resources and working together with common interests makes organizations more innovative because with collaboration, different organizations can learn from each other (Demircioglu & Audretsch, 2020; Martínez-Costa et al., 2019; Tseng et al., 2020). Thus, collaboration has become highly relevant to innovation, particularly when there are agreements of goals, interests, and values across different organizations (Van der Voet & Steijn, 2021).

Traditionally, innovation was conceived entirely as an in-house process carried out in private R&D labs (Romer, 1994). In the early 2000s, however, researchers started realizing that these closed models were obsolete and that innovation was increasingly pursued through open channels where firms (or, more generally, organizations) sourced and shared knowledge to increase their innovation outputs (Bogers et al., 2018; Chesbrough, 2003; Hameduddin et al., 2020). Although open innovation is not directly related to collaboration, Felin and Zenger (2013, p. 914) clarify that the "underlying mechanisms for accessing external knowledge and fostering open innovation have, in turn, encompassed a range of alternatives including contests and tournaments, alliances and joint ventures, corporate venture capital, licensing, open-source platforms, and participation in various development communities." Likewise, in public management, scholars recognized that "bureaucratic (closed) ways of innovating do not yield the quantity and quality of innovations necessary to solve emergent and persistent policy challenges" (Bommert, 2010, p. 15).

Therefore, the concept of open innovation, initially defined by Chesbrough (2006, p. 1) as "a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology", is relevant as cross-sectoral collaborative innovation can be understood as a sub-case of the open innovation model (Gallaud, 2013). Indeed, Gallaud (p. 236) defines collaborative innovation and its rationale as:

> "an organization cooperates with other firms (suppliers, customers, competitors, and consultants) or other organizations (such as universities or public research organism) to develop or commercialize a new innovation. The organizations agree to pool their resources or to share information and knowledge to develop one project, at the end of the project, they keep independent from the legal point of view. The main goal of such collaborative innovation is to gain access to the partner's knowledge and competences especially to tacit knowledge"

Moreover, collaborative innovation can happen in different forms, contexts, and partnerships across sectors: for instance, in the Triple Helix model (university-industry-government), which postulates the dynamism through continuous reorganizations of the innovation collaboration due to cultural and technological evolution (Audretsch & Belitski, 2021a; Etzkowitz & Leydesdorff, 2000), or in the Quadruple Helix model, which adds to this dynamism media-based and culture-based public relations (Carayannis & Campbell, 2009; Miller et al., 2018).

3 On the costs of collaborative innovation: a triple fallacy

Despite these advantages, collaboration demands a more tremendous amount of resources (in time, money, and efforts) and can be unappealing due to several potential costs (Connelly et al., 2014). Furthermore, the risk of collaboration failure is significant: Gulati et al. (2012) report that over 50 percent of collaborative arrangements fail to deliver. Thus, when deciding to collaborate, one should ask whether pursuing innovation through a specific cross-sectoral arrangement is beneficial; that is, whether the benefits outweigh the costs. Since the nature of innovative activities is uncertain, organizations cannot entirely calculate the costs (including risks) and benefits of innovation. However, cost analyses in the context of collaborations for innovation are not well developed in the literature for other three core reasons: the *value* attributed to collaboration, a presumption of the *superiority* of collaboration, and an assumption of the *inevitability* of collaboration.

This first reason has already been mentioned in the introduction: collaboration is increasingly seen as a value in itself (Sørensen & Torfing, 2011; Voorberg et al., 2015). In many instances, collaboration is not a means to achieve objectives but an objective in itself that must be pursued regardless of its merit. Certainly, there are underlying rational reasons to push for collaboration which are related to the uncertainty of innovation. For instance, due to the impossibility of giving an expected value to and to calculate innovation outputs, and due to information asymmetries between actors and sectors, organizations start collaboration to develop trust and get to know each other better (Audretsch & Belitski, 2021b). However, decision on whether—and how—to collaborate to develop innovations should be taken on the basis of rational decision-making focused on processes, an not on ideological presuppositions (Bommert, 2010).

Second, there is a widespread presumption that collaboration is a superior way to pursue strategic objectives (such as innovation) based on an "implicit" cost–benefit analysis; indeed, it is not uncommon that researchers assume that, if we see organizations collaborating, then it means that the benefits of collaboration do outweigh the costs (see Fallis, 2006; Tartari & Breschi, 2012). However, there are at least two significant problems with this approach. One is related to actors' cognitive biases. Individuals and organizations act under bounded rationality; not only do they not possess perfect information (so that they might not know all the costs and benefits related to collaboration), but they might underestimate known costs (Simon, 1976). For instance, Buehler et al. (2005) demonstrate that collaboration exacerbates fallacies in planning; that is, they find that group planning—compared to individual planning—reinforces a bias through which task completion schedules are unrealistically predicted, which results in greater delays. The other problem lies in assuming that the collaborative activity in these cases is discretionary (Tartari & Breschi, 2012), as discretionary activity is associated with net benefits. As mentioned, collaboration is increasingly becoming a mantra, so that researchers reported on several cases of mandated

collaboration in which the collaborative activity was compulsory rather than discretionary (McNamara, 2016; Rodriguez et al., 2007). Thus, as collaboration is increasingly mandated—more or less formally—assuming the positivity of net benefits on the basis that actors are "choosing" to collaborate becomes a contradiction in terms.

Third, cost analyses are sometimes disregarded because collaboration is deemed to be inevitable in order to achieve innovation objectives. This is not always the case, because some organizations may not be willing to collaborate (i.e., ability-willingness paradox), for example family firms that prefer to preserve the affective endowment towards their business (Rondi et al., 2021), or because collaboration may not be necessary when external knowledge can be sourced from other channels without much efforts, such as knowledge spillovers (Audretsch & Belitski, 2020). However, there is a persistent assumption that innovation problems stemming from high degrees of complexity (wicked problems or grand challenges) can be solved only through collaboration (Edmondson, 2016; Head, 2019; O'Toole, 1997). This belief is reinforced by the fact that cross-sectoral arrangements are already complex, and measuring benefits, costs, and performance in these kinds of settings is difficult (O'Toole, 1997). Nevertheless, collaboration is multifaceted and can include diverse arrays of stakeholders: classifying collaboration as "inevitable" reinforces a *black-and-white* fallacy that suggests that only two opposing options are available. In fact, collaboration is a broad concept as it encompasses a great variety of arrangements; indeed, "[t]he phenomenon has been given a variety of names—including alliances, coalitions, community-based collaboratives, networks, and partnerships—and includes a variety of different ways to collaborate" (Connelly, 2014, p. 18).

Various arrangements can be classified based on their degrees of formality and hierarchy (Gazley, 2008). First, arrangements can be formal when based on contracts (such as joint ventures and strong partnerships) or informal when based on noncontractual relationships built between individuals and organizations (Simard & West, 2006). Second, arrangements can vary on the basis of how control is exercised, ranging from cases in which the decision-making power is completely shared (non-hierarchical, horizontal collaboration) to cases that resemble the structure of an organization (hierarchical, vertical collaboration) (Gazley, 2008; Gulati & Singh, 1998; Schuppert, 2011). Thus, "collaboration" can be seen as a continuum of various arrangements with diverse intensities of collaboration rather than as a dichotomous choice, and cost analyses can still serve the purpose of identifying the optimal collaborative solution to an innovation problem.

As innovation studies have already described the benefits of collaborative innovation in great detail, in this article, we tackle the abovementioned gap by developing a comprehensive theory on the costs related to cross-sectoral collaboration for innovation.

4 Towards a cost theory of collaborative innovation

In order to answer our research question on the costs of collaborative arrangements for innovation, we employ three competing explanations—namely, (i) transaction cost economics, (ii) game theory, and (iii) the knowledge-based view—to account for, analyze and integrate relevant findings from innovation studies—such as innovation management, technology management, knowledge management, open innovation, and collaborative innovation research—with literature on collaborative efforts related to network management, collaborative governance, public administration, and organizational theory, as well as with insights from behavioral economics and psychological science studies. As most studies

focus on collaboration and innovation within sectors, we instead emphasize sector-specific studies to the case of cross-sectoral collaborative innovation. Adaptions are needed since findings are not always valid across sectors; nonetheless, "this does not mean that one cannot make inferences about risks and issues from related theories" (Bommert, 2010, p. 26).

4.1 Transaction cost economics of collaborative innovation

Transaction cost economics postulates that agents incur coordination costs to monitor, control, and manage transactions (Hoetker & Mellewigt, 2009; Lee et al., 2015). They will seek the optimal governance structure that can minimize these costs (Williamson, 1981, 1989). As transaction costs are not directly measurable, Williamson (1981, pp. 552–553) explains that a transaction cost analysis considers "the comparative costs of planning, adapting, and monitoring task completion under alternative governing structures". Transaction cost theory can be employed by assuming that (i) "the governance structure that best fits a particular transaction (one with low transaction costs) performs better than one that does not (one with higher transaction costs) (Jobin, 2008, p. 442), and that (ii) collaborative innovation can be approximated to a set of transactions.

By doing so, we argue that differences in cross-sectoral collaborative arrangements will impact the ability of coordinating actors to working together effectively, thus generating differences in transaction costs in the form of higher or lower coordination costs. Coordination is costly, and coordination costs have been found to "constitute an important barrier to the effectiveness and efficiency of joint work in innovative settings" (Vural et al., 2013, p. 134). For instance, Batkovskiy et al. (2015) find that coordination costs are one of the primary challenges and risks in organizational networks to develop innovations in the Russian high-tech industry. Bel and Warner (2015), while comparing European and US studies on inter-municipal cooperation, single out how improper governance structures increase the risk of high coordination costs, which make cooperation between local governments expensive and ineffective. Cummings and Kiesler (2007) also find that coordination costs are detrimental to research outcomes in multi-university research projects.

Coordination costs are thus a significant barrier to collaboration for innovation within and across sectors. However, not all coordination costs are the same. We classify coordination costs under two broader categories: costs related to the *nature of the innovation problem* and costs related to the *structure of the collaboration*. Autonomy, communication, and waiting costs, along with managerial efforts, are part of the former category (coordination costs related to the innovation problem), while formality, hierarchy, size, trust, and geographical location are part of the latter category (coordination costs related to the collaboration structure). We explain these in detail below.

The first element shaping coordination costs is the nature of the innovation problem itself: some problems are much more complex than others (e.g., grand challenges or wicked problems) and require more coordination (Krogh & Torfing, 2015). This is particularly true in cross-sectoral collaborative arrangements, in which the innovation problem is usually complex across many dimensions (e.g., technical, economical, and social) (Edmondson & Reynolds, 2016). Problem complexity can also be expressed by the degree of problem decomposability, that is, the extent to which the innovation problem can be decomposed into independent and non-related tasks (Argyres & Silverman, 2004; Baldwin & von Hippel, 2011). Complex problems exhibit low degrees of decomposability due to a high degree of task interdependence: the more interdependent tasks are, the less autonomy actors have in carrying out their own activities, the more

coordination is required among collaborators, the higher will be the transaction costs (Diener et al., 2015). Thus, in complex innovation problems, coordination costs arising from low autonomy tend to be highly relevant.

Task interdependence is also related to factors that produce other specific costs, which can be categorized as coordination costs. First, when tasks are interdependent, collaborators need to communicate with each other more frequently and intensively; thus, monetary and non-monetary (e.g., time) *communication costs* arise (MacMillan et al., 2004). Second, due to task interdependence, it is common that an actor, before working on his own task, must wait for other collaborators to finish their activities; again, the *cost of waiting* is composed of both non-monetary (e.g., time that an actor needed to wait) and monetary terms (e.g., the salary paid to an actor waiting unproductively) (Camacho, 1991). Third, interdependencies among tasks must be directly managed by coordinators, and this coordinating activity requires greater managerial effort (Rawley, 2010) so *managerial effort* is another cost of collaboration.

The second major element that impacts the coordination costs of cross-sectoral arrangements is the structure of the collaboration. Collaboration among firms, public agencies, governments, nonprofit organizations, research institutions, and/or other societal actors can employ various structures. For instance, Nissen et al. (2014) present the case of a public–private innovation partnership for the development of a prototype trolley in a Danish hospital where the strong and centralized leadership of the private consultant resulted in an effective management of the innovation process. Conversely, Li et al., (2012, p. 61), analyzing cases of cross-sectoral collaboration for social innovation, propose the example of the CDSs (formal bodies called "common denominator subjects") in Hangzhou city in China where "[t]he relations between agents are equal, not a hierarchical one … actors are relatively autonomous in the decision-making process. They act as a new configuration of social agents." Ansari et al. (2001), within the context of health professionals' education in South Africa, suggest that cross-sectoral structures must be clear and well-defined in order to secure effective functioning. However, in other cases, collaboration is looser and less rigid. For instance, exploring cross-sectoral collaborations for homeless services, Berman and West (1995) find that most innovative services are provided through informal arrangements.

As mentioned, these collaborative structures can thus be differentiated based on their degrees of *formality* and *hierarchy* (Gazley, 2008), which are related to transaction costs. First, collaborative agreements with high degrees of formality can reduce coordination costs because "[f]ormalization makes the division of labor and the interactions between partners more predictable" (Gulati & Singh, 1998, p. 786). Additionally, Felin and Zenger (2013) suggest that formal and institutional ties reduce coordination costs as they are essential when upfront investment and commitment are needed to tackle complex problems. However, in organization-like settings, when formality is associated with rigidity, the relationship may be negative. While upfront coordination costs may be lower in formal arrangements, Rawley (2010, p. 9) finds that formality is associated with higher costs of re-coordination since "routines and contracts are costly to change once they are institutionalized." Second, in collaborative arrangements with high degrees of hierarchical control, boundaries are clearer so that tasks, activities, and decisions do not overlap, and decision-making is simplified (Galbraith, 1977). Similarly, Gulati and Singh (1998, p. 784) suggest that hierarchical controls are "superior information-processing mechanisms that result from the increasing division of labor and the uncertainty originating from the need to coordinate interdependent subtasks"; thus, hierarchical governance structure can help reduce transaction costs.

In addition to formality and hierarchy, size, industry type, trust, and institutional location can impact overall transaction costs. The size of the collaboration (i.e., number of actors) is relevant, as large collaborations are costlier to coordinate (Camacho, 1991). Transaction costs are also affected by industry type, such as high technology and knowledge-intensive organizations have become more important than manufacturing and mining sectors, so dynamism and density of transactions have been changing dramatically in recent decades (Hoetker & Mellewigt, 2009). Moreover, transaction costs are different not only across industries but also across sectors due to cognitive distance (Balland et al., 2015). The governance structure, through its rules and controls, can shape trust among collaborators, which deeply affects transaction costs (Becker & Murphy, 1992; de Zubielqui et al., 2019; Gulati & Singh, 1998). Finally, transaction costs are affected by the institutional location of the collaboration; indeed, in countries with more stable and efficient laws, collaborative arrangements tend to exhibit lower coordination costs (Becker & Murphy, 1992). On the contrary, geographical location seems to be irrelevant; for instance, private sector research finds that "[f]irms who collaborate within close proximity will not experience higher innovation than firms collaborating with international partners, illustrating that the limits to collaboration do not increase with geographical proximity" (Audretsch & Belitski, 2019, p. 21).

4.2 Game theory of collaborative innovation

Provided that no single actor is able to advance innovative solutions to complex problems without collaborating, game theory can be employed to understand: (i) what is the optimal way actors can combine resources? (ii) how are they going to form a coalition? and (iii) how do they intend to split the benefits (payoff). While in ordinary games payoff is predetermined, the nature of cross-sectoral collaborative innovation makes it harder to ascertain. First, innovation is a risky activity, which may end in failure (zero payoff), and whose outcome is highly unpredictable, thus causing frequent disagreements over the innovation strategy (Walsh et al., 2016) and conflicts over competing goals (Torugsa & Arundel, 2016). On the other hand, in cross-sectoral coalitions actors will assign diverse values to the actual payoff, as they seek innovation for different reasons. Thus, what can be highly valuable to one actor (e.g., profit to a firm) may be less valuable to others (e.g., a public agency) (Nissen et al., 2014). Therefore, collaborative innovation can be interpreted as a cooperative cost game (Curiel, 2013) in which actors will tend to form a grand coalition to share the costs related to an activity (i.e., innovation).

Analyzing the costs of cross-sectoral collaborative innovation in light of cooperative game theory thus means to answer the question "provided that actors will share the costs of the innovation process, what are the factors impacting their decision-making and negotiations on how to split them optimally?". These factors will relate to all the ex-ante measures (e.g., monetary and non-monetary incentives) needed to make different and idiosyncratic values and ambitions compatible. The magnitude of these costs is dependent on several characteristics of the collaborators, such as power, trust, reputation, and commitment. Cooperative game theory suggests that powerful actors (e.g., actors that possess fundamental resources to solve the innovation process, or so called "veto players") will mostly impact the cost allocation, thus making divergence among them costly to the overall process (Schoon & York, 2011). However, in order for cooperation to emerge and endure among all players, trust is a primary requirement. Indeed, collaborations are effective only if actors have "the confirmation that participants in a collective endeavor are trustworthy

and credible, with compatible and interdependent interests" (Emerson et al., 2012, p. 14). When trust is lacking, perceived risks related to opportunism demand that organizations put in place higher levels of control towards partners' activities using pragmatic mechanisms in order to align the divergent interests of the collaborators (Helper et al., 2000). These measures divert organizational resources away from other uses, thus increasing the total cost of the collaboration.

Another factor that can impact the total cost is reputation, which can be defined as "historical trustworthiness" (Christiansen & Vandelø, 2003, p. 310). Reputation is complex to build and requires active and prolonged engagement with stakeholders along with the motivation towards co-decisional processes (Romenti, 2010). Reputation can also be formed in the initial phases of a collaboration but requires organizations to invest resources in reputation-building activities that demonstrate collaborators' skills and competences and foster professional interactions (Christiansen & Vandelø, 2003). Santos et al. (2018) find that when reputation building is too costly, cooperation can still emerge if actors report their interactions, thus creating a reporting cost for organizations (e.g., time and effort to write web pages).

Moreover, collaboration effectiveness is also deeply dependent on the commitment of collaborators to work towards common and shared goals (Gazley, 2010). Roxenhall and Andrésen (2012) find that commitment[2] is crucial when starting new collaborations. Hammarfjord and Roxenhall (2017), linking commitment and innovation, demonstrate that commitment positively mediates the relationship between collaboration and innovation, such that organizations tend to be more innovative when commitment is higher. More specifically, commitment has been operationalized as whether organizations "feel strongly associated with the network", "have positive feelings for the network", "ought to continue to be part of the network", and the organization believes that "the network problems almost feel like our own problems" (Hammarfjord & Roxenhall, 2017, p. 30). Similarly, however, as seen from the studies of commitment and its operationalization, commitment is not easy to establish and maintain, and highly subjective (Hammarfjord & Roxenhall, 2017).

A cooperative cost game can be analysed also through non-cooperative game theory, which suggests that within a coalition, each individual will aim at maximising its payoff. In this sense, collaboration presents indirect costs which are the risks associated with reduced effectiveness (including the extreme case of innovation failure) due to incompatibilities. Indeed, divergent interests can lead to the risk of innovation failure; Krogh and Torfing (2015, p. 103) explain concisely that "[w]hile minor conflicts may be fruitful in the sense that they force the actors to sharpen their ideas and arguments and revise their proposed solutions, serious conflicts may destroy collaboration and create insurmountable deadlocks that prevent innovation." For instance, Rodriguez et al., (2007, p. 173) report that, in the context of an organizational innovation for improving elderly services in urban region of Canada, a "great deal of energy was expended in committees, information sessions, and training programs. However, 6 months after the so-called 'D-day' when the program was

[2] Commitment can be divided into three components that differently affect collaborative costs: affective, calculative, and normative commitment (Roxenhall & Andrésen, 2012). The affective (or emotional) component is based on common values and relationships of trust, so that in long-established collaborations, actors would have higher levels of affective commitment. The calculative component is based on individualistic, business-like standards: organizations would have higher levels of calculative commitments if prior investments in the collaboration created situations of "lock-in" or if there are no feasible alternatives. Finally, the normative (or moral) component is based on feelings of responsibility towards the collaboration.

due to be implemented, a senior Regional Board official declared it 'dead.'" Divergent values and goals can also compromise consolidated collaborations, undoing all previous investments (such as setting up a coordinating structure or building relations of trust) (Connelly et al., 2014) and thus compromising systemic innovation processes.

Finally, another kind of cost occurs when the innovation does not fail, and its effectiveness is not impaired, but the innovation benefits are appropriated by a single actor, or when incentive mechanisms set up to align interests perversely contribute to further misalignment. For instance, Bommert (2010, p. 26) explains that, in the context of private–public collaborations, "actors have the possibility to manipulate the elements of the innovation cycle to exert their particular interests over the goal of innovating public value." Likewise, Hartley et al., (2013, p. 826) find that "collaborative innovation may be at risk when particular private actors are able to capture the collaborative arena and exploit the process of innovation and its result to their own advantage."

4.3 Knowledge-based view of collaborative innovation

A third major explanation of the costs associated with cross-sectoral collaboration for innovation is the knowledge-based view of collaborative innovation, which suggests that competing collaborative arrangements will impact knowledge flows, occurring "whenever an idea generated by a certain institution is learned by another institution" (Peri, 2005, p. 308). While learning and knowledge sharing remain some of the primary rationales for innovation (Du Plessis, 2007), costs that are incurred for the acquisition of relevant external knowledge (i.e., knowledge inflows) and for the retention of confidential internal knowledge (i.e., knowledge outflows) cannot be disregarded when deciding to collaborate.

Undoubtedly, knowledge sharing is an essential feature of collaborative innovation settings; traditionally, it has been the driver that pushed researchers and practitioners to move away from in-house R&D-based innovation models and to look beyond firm's boundaries for the development and implementation of innovations (Baldwin & von Hippel, 2011; Chesbrough, 2003). In particular, primary importance has been given to external knowledge sourcing, which is defined as an organization's "tendency to use knowledge from beyond its boundaries through a wide range of external channels" (Asimakopoulos et al., 2020, p. 123). Consistent with the economics theory of bounded rationality (Simon, 1976), knowledge sourcing and acquisition are expensive and somewhat unexpected processes: agents have limited resources when looking for relevant external knowledge and selecting for potential partners and appropriate collaborations. This limitation can be exacerbated by the *hiddenness* of knowledge: the location of the knowledge required to solve an innovation problem is not always revealed, and it is typical that actors are unaware of the location of relevant knowledge (Felin & Zenger, 2013). Thus, a first cost related to knowledge flows is associated with the *cost of knowledge sourcing*, which comprises all the costs relating to identifying and acquiring knowledge.

Subsequently, even when collaborators have been found and knowledge acquired, it may still be the case that some important knowledge for the innovation process resides beyond the "collaboration's boundaries"; that is, collaborators may not possess all significant information, skills, and ideas to effectively develop, implement, or diffuse the innovation. In other words, the question becomes: is all relevant knowledge needed to solve the innovation problem contained within the boundaries of the cross-sectoral collaboration? In this regard, Minson and Mueller (2012, p. 200) find that, when collaborating, actors tend to feel more effective, and this induced feeling tends to inhibit the exploration of external

knowledge since "the mere act of collaborating enhances confidence, and thereby limits receptivity to outside advice," which reduces effectiveness. A second cost related to knowledge flows is thus a *confidence cost*, which is related to the cognitive risk of limiting the knowledge search to the collaboration's boundaries, thus increasing the risk of omitting relevant information needed for the innovation process.

Copious research has also pointed out that in order to be beneficial to the innovation process, external knowledge acquisition must be coupled with internal *absorptive capacity* (see e.g. Cohen & Levinthal, 1990; Tsai, 2001; Vanhaverbeke et al., 2008). This concept has traditionally been a private sector construct (Van den Bosch et al., 2003) since it is defined as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990, p. 128). Nevertheless, new information is required for the innovation process in all kinds of organizations, regardless of their sector, since "[a]ll organizations are to some extent knowledge intensive" (Willem & Buelens, 2007, p. 582). Therefore, all organizations need to invest in and build a capacity to first absorb and then exploit external knowledge, and these investments are costly, multifaceted, and difficult to evaluate (Cohen & Levinthal, 1990; Kostopoulos et al., 2011). Investments in absorptive capacity also represent an example of the higher costs incurred by cross-sectoral collaborations, as actors collaborating within the same sector usually have general experience and knowledge to sufficiently understand external knowledge flows.

Indeed, in the context of cross-sectoral collaborative innovation, even if organizations already have significant absorptive capacities, further investments may be required, as extant capacity may be incoherent with the acquisition of *extra-sectoral knowledge*, which is knowledge pertaining to different sectors. For instance, in the context of industrial innovation, Cohen and Levinthal (1990, p. 144) suggest that "one important determinant of the ease of learning is the degree to which outside knowledge is targeted to a firm's needs and concerns" and that "the ability to evaluate and utilize outside knowledge is largely a function of the level of prior related knowledge" (p. 128). Across sectors, knowledge is different in nature. It is mainly *targeted* and *related* to sectoral needs; for instance, knowledge sourced from universities is typically targeted to educational and research needs, so that it is less concerned with firms' purposes (Vega-Jurado et al., 2009). This is highly relevant for cross-sectoral collaborations; in order to effectively exploit extra-sectoral knowledge, diverse expertise is required and must be built since, in the absence of appropriate knowledge bases, organizations may not be able to absorb new knowledge (Terjesen & Patel, 2017). However, although the effects of knowledge diversity from collaboration contributes to generating new knowledge, some studies find that its marginal benefit to innovation may decrease due to process losses, integration, and capacity (Cummings & Kiseler, 2007; Nooteboom, 2008; Van Knippenberg et al., 2004). Therefore, a third cost related to knowledge flows is identified as the *cost of capacity building* for exploiting extra-sectoral external knowledge.

Once collaborators are identified and adequate capacity is built, transferring knowledge within a collaborative arrangement may be more or less costly, depending on several factors. For instance, Wathne et al. (1996) list four main factors that facilitate knowledge flows. First, knowledge transfer is found to be ineffective when collaborators do not exhibit an open and transparent attitude. Within the context of cross-sectoral collaboration, collaborators may have different to divergent values, so that openness and transparency become crucial elements to limit the costs of collaborative innovation. Second, costs related to knowledge transfer arise whenever there are misinterpretations. Wathne et al. (1996) classify this factor as the channel of interaction: when knowledge is transferred through channels that allow information to be shared the most clearly (e.g., face-to-face interaction vs.

email interaction), collaboration is more efficient. In this regard, Felin and Zenger (2013) find that the governance structure of formality is positively associated with the richness of the channels of interactions, such that within informal structures knowledge transfers may be more costly. Third, to secure effective knowledge transfers, collaborators must be in a relationship based on mutual efforts and trust (Hoetker & Mellewigt, 2009). Ring and Van de Ven (1992, p. 489) explain that, in order for trust to emerge, at least three conditions must be met:

> (1) reciprocity, by which one is morally obligated to give something in return for something received … (2) fair rates of exchange between utilitarian costs and benefits … and (3) distributive justice, through which all parties receive benefits that are proportional to their investment.

If these conditions are unmet, collaborators do not perceive themselves as equals. When equity and trust are lacking, actors may be obliged to take preventive measures that increase the costs of knowledge transfer. Fourth, Wathne et al. (1996) conclude that prior experience in collaborating with specific partners eases knowledge transfers. Therefore, newly formed collaborative arrangements are, on average, more costly than consolidated ones regarding the transfer of knowledge.

Finally, knowledge flows entail costs not only in letting relevant knowledge "flow in" or "flow within" (e.g., sourcing, absorbing, and transferring) but also in preventing confidential knowledge from "flowing out." We categorize these costs (and risks) as *exposure costs*, which have been reported across sectors in various fields. One example is the risk of relevant and valuable in-house R&D leaking out not only to collaborators, but also to "competitors through common suppliers or customers" (Cassiman & Veugelers, 2002, p. 1179), thus requiring additional control costs. Laursen and Salter (2014) refer to this problem as the *paradox of openness*: although firms need openness to develop innovations, they also need to put in place strategies to appropriate the monetary benefits deriving from innovation and to protect themselves from competitors, thus incurring costs and risks. Referring to the public sector context, Hartley et al., (2013, p. 826) state that some public authorities must deal with needs for confidentiality, as "collaboration may compromise public security, compromise the privacy of private firms and citizens, or harm the interests of public enterprises." Similarly, in the context of research institutions, Macfarlane (2017) recognizes that while scholars need collaborations for various ends (e.g., increasing productivity), knowledge sharing can also be counterproductive as scholars are pressured to develop independent research and individual achievements in order to be promoted.

4.4 Integrated cost theory of collaborative innovation

Based on the integration of the theoretical explanations presented above, we argue that four main factors and their interplay need to be analyzed to determine the optimal collaborative arrangement that can minimize the costs incurred by collaborative innovations:

Governance, in terms of the number of collaborators and the hierarchical relationships among them.
Compactness, in terms of the degree of relationship formality that binds collaborators together.
Reliability, in terms of the quality of the relationships (e.g., level of trust, commitment, and reputation among collaborators).

Institutionalization, in terms of the extent to which the relationships have been pre-established by practice.

Table 1 summarizes these main factors constituting the integrated cost theory of collaborative innovation (ICT), their explanation provided by the transaction cost economics, game theory, and knowledge-based view of collaborative innovation, and their expected impact on the costs of collaborative innovation.

5 Discussion and implications

When attempting to innovate, organizations can choose whether to do so internally or through collaboration. Moreover, organizations can choose among several collaborative arrangements and prioritize some over others when collaborating with various actors. Collaboration is costly; cross-sectoral arrangements may particularly present even higher costs (e.g., due to knowledge diversity and interest divergence). Thus, rigorous analyses on the merits of such collaborations should be advanced. However, we observe a loose matching between this need and the current positioning of collaborative innovation in the literature.

The purpose of this article was to obtain a better understanding of the process underlying collaboration for innovation and to identify the potential costs incurred in these collaborative settings specifically. In this regard, we believe that our article has several implications. First, we developed and advanced a cost theory for cross-sectoral collaborative innovation that encompasses, merges, and integrates studies from different research fields in light of three major economic theories (transaction cost theory, game theory, and knowledge-based theory). This approach reflects the many diverse phenomena involved in the management of cross-sectoral collaborations and thus shares the "epistemic value of having theories that unify a wide range of phenomena" (Fallis, 2006, p. 201). Our conceptualization of the main factors affecting collaborative innovation costs (i.e., governance, compactness, reliability, and institutionalization) adapts and models extant knowledge on the costs of collaborative arrangements and makes it explicit on an abstract and conceptual level, which allows scholars to examine broader research questions.

A second epistemic implication of this study resides in the explicit acknowledgement of the weaknesses and limitations in the current discourse on collaborative innovations. While "[i]dentifying problems in the empirical literature can serve a valuable scientific function" (Baumeister & Leary, 1997, p. 312) as it allows researchers to recognize knowledge gaps and to correct its direction, we also explain the reasons for this gap—namely, the assumptions of the value attribution, superiority, and inevitability of collaborative innovation. Furthermore, this article avoids positing a further dichotomous "black-or-white" fallacy; that is, our approach dismisses divisive arguments on whether to collaborate or not and brings into focus the continuum of the various "gray" alternatives, as cross-sectoral collaborative arrangements can take completely different forms (i.e., have diverse degrees of collaboration based on the extant governance, compactness, reliability and institutionalization) and thus have different costs within the innovation process. Moreover, within this approach, a crucial question becomes how to reduce the costs or limitations of collaborative innovation. Audretsch and Belitski (2019) suggest that focusing on human capital, prioritizing a few partners for collaboration (instead of aiming to collaborate with too many actors), and better coordination can help to reduce barriers and costs. In this regard, policymakers may focus on reducing the costs of collaborative innovation as well as understanding the costs

Table 1 Main factors of the Integrated Cost Theory (ICT) of collaborative innovation, their impact, and explanations

ICT factors	Transaction cost economics	Game theory	Knowledge-based view
Governance Overall Impact: **unclear** The number and type of actors, and the hierarchical relationships among them (vertical or horizontal) will shape the costs differently	The higher the number of collaborators, the greater the costs to coordinate them will be (Camacho, 1991) However, vertical relationships can improve the division of labor and reduce costs of overlapping (Galbraith, 1977; Gulati & Singh, 1998) The chosen governance structure (size, hierarchy) can also impact costs via higher/lower reliability (Becker & Murphy, 1992; de Zubielqui et al., 2019)	The costs related to governance will depend on the nature of the grand coalition in terms of total number of players, numerosity of veto-players, and the divergence of interest among these powerful actors (the higher their divergence, the greater the costs) (Schoon & York, 2011)	The type and origins of collaborators, in terms of their absorptive capacities) will impact the costs of capacity building: even if organizations already have significant absorptive capacities, investments may be required as extant capacity may be incoherent with the acquisition of extra-sectoral knowledge, which is knowledge pertaining to different sectors (Cohen & Levinthal, 1990)
Compactness Overall impact: **positive** Compact agreements reduce the costs related to coordination, opportunism, and knowledge transfers	The more compact relationships are (e.g., a stipulation of binding agreements, formation of a new legal entity), the lower the costs of coordination due to savings in communication, waiting, and managerial efforts (Gulati & Singh, 1998)	The costs related to compactness will depend on the characteristics of the game (i.e., of the innovation problem): when cooperative game theory holds, binding agreements are possible; under non-competitive game theory, it is not possible to form binding agreements, so that costly controls against opportunism are necessary (Krogh & Torfing, 2015)	Compactness improves the richness of channels of interactions among collaborators, reducing the costs of transferring knowledge (Wathne et al., 1996) Moreover, binding agreements can reduce the pressures of exposure and confidentiality (Cassiman & Veugelers, 2002)
Reliability Overall Impact: **positive** Quality relationships reduce collaboration costs and have a reinforcing effect on compactness	Quality relationships (e.g., based on trust among collaborators) are associated with lower coordination costs (de Zubielqui et al., 2019)	Quality relationships will ease the process of negotiation for the allocation of collaboration costs. (Emerson et al., 2012) Moreover, trust among players will ease the application of cooperative game theory, reducing costs via improved compactness (Christiansen & Vandelø, 2003; Emerson et al., 2012)	Quality relationships (i.e., based on trust and transparency) will ease knowledge transfers, reducing overall costs of collaboration (Hoetker & Mellewigt, 2009)

Table 1 (continued)

ICT factors	Transaction cost economics	Game theory	Knowledge-based view
Institutionalization Overall impact: **unclear** Institutionalization may cause rigidity and over-confidence, but can also increase commitment and reinforce the reliability	Institutionalized relations may exhibit rigidity, which increases the coordination costs when tackling a new innovation problem (Rawley, 2010) However, pre-established formal and institutionalized relations can have a positive impact on costs via improved reliability (Felin & Zenger, 2013)	Institutionalized relations will ease the process of negotiation for the allocation of costs, via higher levels of players commitment (e.g., affective, calculative) and improved reputation (Gazley, 2010; Romenti, 2010)	Institutionalized relations will present a confidence bias, making the costs of knowledge sourcing higher (Minson & Mueller, 2012) However, pre-established relations can ease knowledge transfers (Wathne et al., 1996)

of these types of innovations. For instance, different types of costs may be incurred during different stages. Transaction costs may occur after deciding to collaborate while cooperation and knowledge costs may occur in early stages. Additionally, some coordination is required in the beginning to decide how to divide tasks and may be relevant when deciding whether to collaborate. Other knowledge costs (such as confidence costs) should be managed during the collaboration to ensure that all relevant knowledge is acquired. Nevertheless, all three types of costs may occur at any stage of the collaboration process.

Additionally, this study contributes to the literature by providing a systematic and coherent framework for making sense of the empirical findings of recent research by demonstrating that there are tradeoffs in terms of costs and benefits to be considered. For instance, while knowledge sourcing pushes organizations beyond their boundaries to innovate, Asimakopoulos et al. (2020) show that sourcing externally is an efficient strategy only for moderate levels of collaboration and that in some situations the actual costs of sourcing outweigh the benefits, so that sourcing externally is not beneficial and other strategies are to be preferred (e.g. internal development). Thus, this article explains why collaboration is not a panacea for organizations, and policymakers should recognize its costs and limitations.

We mentioned that one of the arguments in favor of collaborative innovation is that alternatives (e.g., closed modes of innovation) are said to be inappropriate to solving wicked problems (e.g., Bommert, 2010)—that is, the assumption that collaboration is inevitable. This study contributes to this debate. We, along with the analysis resulting from the three economic theories employed in this study, suggest that the problem resides in the identification of the optimal conditions of collaboration for a specific innovation problem. In other words, the question should be which collaborative arrangements (among the many possibilities) solve the complex innovation problem while minimizing the costs of collaboration. We identified the salient factors that can shape the cost structure of a cross-sectoral arrangement, such as the formality and hierarchy of the governance structure or the level of trust among collaborators. However, as shown, collaboration itself is not inevitable as collaborative arrangements do impose higher costs when solving complex problems. For instance, coordination becomes costlier (e.g., due to greater communication costs, waiting times, and managerial efforts). While communication costs have been drastically reduced by the diffusion of ICT (Shin, 1997), the costs of waiting and directly managing interdependencies are still highly relevant in the context of collaborative arrangements for innovation, as innovation problems are generally complex. Recognizing that complex problems incur greater costs to be coordinated allows us to ask whether a specific collaborative arrangement is feasible or new solutions must be advanced. Indeed, recent practices can help reduce these coordination costs for highly complex problems; for instance, modularization aims at "innovatively transforming previously complex, non-decomposable problems into simpler, more decomposable problems" (Felin & Zenger, 2013, p. 923).

We argue that collaboration should be critically evaluated and not pursued for its own sake. However, this article also has implications for the question of whether we should systematize and pursue collaboration even when costs outweigh benefits. Scholars frequently call for the systematization of collaborations due to the benefits of experience (e.g. Cummings & Kiesler, 2008; Murphy et al., 2015), and our cost conceptualization provides some theoretical justifications for this call. Indeed, institutionalized collaboration seems to be comparatively more efficient than impromptu modes; for instance, as Wathne et al. (1996) and Ring and Van de Ven (1992) suggest, prior experience in collaborating with an actor reduces costs of knowledge transfer and enhances trust, which in turn reduces all three major categories of costs (transaction, knowledge, and cooperation). Due to these

factors, when collaborations are consolidated, we may expect to see reduced collaboration costs and systemic collaborations that are relatively more advantageous, which may justify the positioning of collaboration as having a "value in itself"; even if the present costs of collaboration are higher than the benefits, the promise of declining collaboration costs over time may be enough to justify an investment in collaborative assets.

Nevertheless, regardless of the attractiveness of these conclusions, our integrated model debunks these assumptions. While it is true that in systemic collaborations several costs are reduced, we shed light on the actuality that even institutionalized collaborations are not free of costs and are likely to be more expensive. For instance, when collaboration is systematized, new coordination costs may occur due to rigid routines, offsetting the gains in coordination due to enhanced trust. Again, wicked problems may need fast adaptions and require frequent re-coordination, which may be less likely to happen in a consolidated collaborative arrangement. Furthermore, systematized collaborations may incur higher knowledge costs due to increasing confidence costs: once a specific arrangement is set, actors may be too reliant on their own capacities and miss external learning opportunities that may be crucial to solve new and complex problems. When flexibility and permeability are crucial to solving an innovation problem, a careful comparative cost analysis suggests that seeking a novel, fresh, "innovative" collaboration may be preferable to extant arrangements, even if trust was created.

6 Conclusions

There is growing interest in analyzing collaborative innovation because innovation is pursued through the cross-sectoral collaboration of different sectors and organizations. This interest is primarily justified by the (untested) assumptions that collaboration is conducive to innovation, that it is able to solve organizational and socio-economic problems, and that it can deal with grand challenges or wicked problems. However, there are not enough studies that provide empirical evidence regarding the costs of such collaborative engagement. In fact, collaboration can be detrimental and costly, and the main contribution of this article is to provide a theoretical framework for the costs associated with collaborative innovations. We provide a framework analyzing why and how explanations of transaction cost theory, game theory, and knowledge-based theory constitute the main costs of collaborative innovation. More specifically, we suggest that transaction costs derive from the nature of the innovation problem and the structure of the collaboration, cooperation costs derive from the costs of making idiosyncratic interests compatible and the indirect costs of innovation failure or opportunism, and knowledge costs derive from the need to manage both inflows and outflows of knowledge.

We recommend that future studies evaluate collaboration using rigorous models, and the framework we present in this article is a first step toward developing these models. Future research may need to systematically analyze when collaborative innovation is beneficial in order to develop explicit models that simultaneously evaluate the costs and benefits of collaborations for innovation and advance the measurement of such collaborations. Additionally, this study identified the costs, or disadvantages, of innovating through cross-sectoral collaborations. Future research may integrate these two aspects and evaluate, both theoretically and empirically, the conditions and cases under which collaboration benefits outweigh costs, making cross-sectoral collaborative arrangements beneficial for innovation. Finally, in this article we addressed the "how" to collaborate in order to reduce costs

of collaborative innovation; future studies may consider the issue of extent of the collaboration (i.e., intensity) to categorize collaboration into heterogeneous modes and ask "how much" or "how less" collaborative innovation could be pursued.

Collaborating actors should be aware of the importance of determining an optimal governance structure that allows them to minimize transaction, knowledge, and cooperation costs, and they should design the innovative process such that each participating actor is rewarded proportionally to the cost they bear in order to foster conditions of reciprocity, fair rates of exchange, and distributive justice (Ring & Van de Ven, 1992). This can only be achieved with a proper understanding of the costs of collaboration and how they are distributed across collaborators.

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