Science and Public Policy, 46(4), 2019, 490–503
doi: 10.1093/scipol/scz002
Advance Access Publication Date: 7 February 2019
Article

The relationship between organizational interdependence and additionality obtained from innovation ecosystem participation

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Abstract

Despite the increased interest in innovation ecosystems, few studies have assessed the extent to , which the proclaimed benefits from participating in such ecosystems also occur, and under which circumstances they do occur. Uniting the literature on organizational interdependence and social exchange theory, we assess the behavioral and output additionality obtained by innovation ecosystem participants. In doing so, we build upon a sample of 473 innovative Finnish companies, of which 312 participated in an innovation ecosystem. We find a significantly positive relationship between organizational interdependence and output additionality, and find that this relationship is mediated by behavioral additionality. Furthermore, we find that the relationship between behavioral additionality and output additionality is particularly strong when firms appoint members from the innovation ecosystem to their board of directors, pointing to the importance of internalizing the ecosystem. We discuss implications for academia and practice.

Key words: innovation ecosystem, social exchange theory, organizational interdependence, additionality

1. Introduction

It is commonly accepted that firms do not operate in isolation, but frequently interact, collaborate, and depend on each other for realizing their goals (Gnyawali and Park 2009; Chen and Miller 2012). In order to overcome such organizational interdependencies, firms engage in, among others, alliances, collaborations, open innovation, and networks (Coombs et al. 2003; De Man and Duysters 2005; West et al. 2014). Recently, researchers have pointed innovation ecosystems as an alternative way in which relationships between firms are structured. Oh et al. (2016) indicate that the term 'innovation ecosystem' is not a rigorously defined construct, and point to Jackson's (2011) broad definition of the phenomenon, defining it as 'the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation'. In innovation ecosystems, actors work cooperatively and competitively to co-create new products and services (Moore 1993; Nambisan and Baron 2013), hereby sharing a common set of goals and objectives just as knowledge and skills (Adner and Kapoor 2010; Nambisan and Baron 2013).

As a rationale for the engagement in innovation ecosystems, scholars have consistently pointed to the potential impact of such engagement on firm performance (Moore 1993; Cusumano and Gawer 2002; Iansiti and Levien 2004; Li 2009). Indeed, innovation ecosystems are supposed to offer firms resources to navigate through a constantly changing environment (Zahra and Nambisan 2012) and are considered to bring competitive advantages for each of the partners (Clarysse et al. 2014). At the same time, few studies have actually assessed the ecosystem's contribution to resources, value creation, and eventual firm performance (Adner 2006; Tencati and Zsolnai 2009; Adner and Kapoor 2010; van der Borgh et al. 2012; Li and Garnsey 2013). Indeed, so far, the innovation ecosystems literature has mainly analyzed ecosystems from the perspective of their orchestrators, hubs (Moore 1993; Iansiti and Levien 2004; Autio and Thomas 2013), or platform leaders (Iyer and Davenport 2008; Isckia 2009; West and Wood 2013; Gawer and Cusumano 2014; Wareham et al. 2014). As such, despite the presumed benefits of ecosystem engagement, it is still unclear to which extent such participation is beneficial to the 'average' innovation ecosystem participant, and under which circumstances this is the case (Hyrynsalmi et al. 2015).

By consequence, this article aims at addressing the following broad research question: '*Under which circumstances do firms derive advantages from participating in an innovation ecosystem?*'. Integrating social exchange theory (Blau 1964; Narasimhan et al. 2009) and the innovation ecosystem literature, our base premise is that the level of firm organizational interdependence is positively related to the benefits obtained from innovation ecosystem participation. By consequence, our specific research question can be formulated as follows: '*How and when is firm organizational interdependence related to innovation ecosystem impact?*'. In order to assess innovation ecosystem benefits, we build upon Falk's additionality framework (2007), hereby specifically focusing on output additionality (i.e. the impact on firm performance) as the ultimate outcome. Next to assessing the direct relationship between organizational interdependence and output additionality, we aim at disentangling the process through which output additionality is realized, hereby hypothesizing and testing for (moderated) mediated relationships.

In order to reach our research objectives, we build upon a representative sample of 473 Finnish innovative firms for which firm-specific information and information on ecosystem participation and benefits were collected through telephone interviews and subsequently matched with secondary data. By consequence, this study pays attention to all types of innovation ecosystem players, irrespective of their position in the ecosystem. In addition, our data coverage enables us to capture firms that are active in diverse sectors, going beyond the typical innovation ecosystem focus on firms from the ICT sector (Dedehayir and Mäkinen 2011; Seppälä and Kenney 2012; West and Wood 2013; Gawer and Cusumano 2014). Our article unfolds as follows. First, we elaborate on our theoretical framework. Next, our methodology and results are presented. Finally, our findings are discussed, just as the contributions to research and practice, and future research directions emerging from our study.

2. Theoretical framework

In what follows, we elaborate on the relationship between organizational interdependence and the benefits obtained from innovation ecosystem participation. Particularly, we aim at disentangling this relationship by identifying potential mediating and moderating factors. In order to do so, we integrate social exchange theory with the innovation ecosystem and organizational interdependence literatures.

2.1. Organizational interdependence

It has been well acknowledged that the environment largely impacts the organization (Thompson and McEwen 1958; Cyert and March 1963; Katz and Kahn 1966) and that important transactional interdependencies between organizations exist (Aiken and Hage 1968). Interdependence between organizations can create problems of uncertainty and unpredictability (Pfeffer and Salancik 1978). In such circumstances, the most common solution is to increase coordination, leading to tighter and more manageable interdependencies (Pfeffer 1972; Pfeffer and Salancik 1978). Indeed, Gulati and Gargiulo (1999) indicate that organizational interdependence is the most common explanation for the emergence of cooperative ties such as strategic alliances and inter-organizational networks. Along the same lines, Pfeffer (1972) and Pfeffer and Nowak (1976), respectively, refer to such interdependence as the driver for firm engagement in mergers and joint ventures. Recently, researchers have pointed to alternative ways in which relationships between interdependent firms are structured, such as innovation ecosystems that constitute the objects of our study.

2.2. The relationship between organizational interdependence and innovation ecosystem impact

By consequence, we first argue that, as organizational interdependencies lead firms to engage in the formation of different types of inter-organizational ties and networks (Gulati and Gargiulo 1999), especially firms experiencing higher levels of interdependencies will benefit from such engagement. In what follows, we build our arguments for linking organizational interdependence and ecosystem participation benefits, hereby integrating the literature on organizational interdependence with social exchange theory.

While applicable to a wide range of domains, including labor division, decision making, and political behavior (Emerson 1976), social exchange theory also has the ability to deeply understand inter-organizational relations (Emerson 1976; Das and Teng 2002; Narasimhan et al. 2009). Cropanzano and Mitchell (2005) even indicate that it is one of the most influential paradigms in organizational behavior. Specifically, the theory suggests that individuals, groups, or organizations interact with the expectation of a reward from such interaction (Homans 1958; Emerson 1976), referred to as productive exchange (Emerson 1976) or reciprocity, which can be restricted or generalized (Das and Teng 2002), with the first applying to interactions between two parties and the latter to multiparty exchanges. Along the same lines, Blau (1964) indicates that social exchange is concerned with actions that are contingent on rewarding reactions from others. Potential productive exchange rewards are then referred to by Foa and Foa (1980) as economic and socioemotional outcomes. Cropanzano and Mitchell (2005) subsequently explain that economic outcomes are financial and tangible, whereas socioeconomic outcomes are more related to esteem and prestige. As such, as we argue, organizations are likely to benefit from innovation ecosystem participation if they are confronted with strong organizational interdependencies, as such participation will help them to structure and manage these interdependencies. Furthermore, following social exchange theory, organizations within an ecosystem interact with each other with the expectation of rewards, which can be economic or socioemotional.

The literature on innovation ecosystems supports the assertion that organizations may pay attention to potential innovation ecosystem benefits when engaging in interactions in one. Indeed, ecosystem reputation may benefit its residents (van der Borgh et al. 2012) and innovation ecosystem participation may help members to navigate through a volatile environment (Zahra and Nambisan 2012), giving direction and reducing uncertainty. By mobilizing ecosystem resources, firms can further mitigate innovation risks upstream and downstream (Li and Garnsey 2014) and benefit from cross-industrial complementarities (van der Borgh et al. 2012). Importantly, additional complementary resources can facilitate the generation of a potentially large number of complementary innovations (Gawer and Cusumano 2014). Other proclaimed benefits include the access to established markets, branding and reputation advantages, access to technical know-how and intellectual property, and better IPO opportunities (Eisenmann et al. 2009; Ceccagnoli et al. 2012). Some innovation ecosystems further help in increasing product variety, lowering production and inventory costs, and reducing time to market (Gawer and Cusumano 2014). Ultimately, collaborations in an ecosystem are expected to lead to superior performance (Tencati and Zsolnai 2009). By consequence, a social exchange theory perspective is particularly relevant as, following the innovation ecosystem literature, significant benefits can be achieved from interacting with parties in the innovation ecosystem. It is in this respect further important note to social exchange theory and the embedded notion of productive exchange (and particularly generalized reciprocity) accommodate large numbers of actors (Emerson 1976; Das and Teng 2002; Cropanzano et al. 2017), in contrast to other theories that are purely applicable to dyadic interactions. The nature of innovation ecosystems, typically hosting a wide range of actors (Oh et al. 2016) then emphasizes the relevance of our selected theoretical perspective.

As such, building on the theoretical frameworks of organizational interdependence and social exchange, in combination with the literature on innovation ecosystems, we argue that, when organizations experience higher levels of organizational interdependence, they are more likely to reap benefits from innovation ecosystem participation. This effect can be expected to occur irrespective of whether or not the focal firm deliberately belongs to the innovation ecosystem. An important challenge then relates to the measurement of such benefits. A particularly useful instrument for measuring outcomes from innovation policy measures is the additionality framework developed by Falk (2007). We deemed this framework particularly relevant for our research objectives, given the increased interest in, and support by, policy makers to innovation ecosystems (Li and Garnsey 2014; Järvi and Kortelainen 2016). Furthermore, while Falk's conceptualization of effect measurement originated from an attempt to measure the effect of R&D subsidies (Aerts and Schmidt 2008; Clarysse et al. 2009; Herrera and Sanchez-Gonzalez 2013; Wanzenböck et al. 2013) and R&D programs and policies (Hsu et al. 2009; Cerulli et al. 2016), the instrument has been frequently applied to other types of interventions and mechanisms. For instance, the additionality framework was applied to measure the impact of subsidies for research cooperation (Teirlinck and Spithoven 2012), support programs for the commercialization of university research (Gulbrandsen and Rasmussen 2012), technology intermediaries (Knockaert et al. 2014; Knockaert and Spithoven 2014), and regional and European innovation policies (Luukkonen 2000; Antonioli et al. 2014). Particularly of interest to our research goals, and in particular to the study of the occurrence of economic rewards in line with social exchange theory, is the notion of output additionality.

Output additionality deals with the most decisive impact, namely the impact on the firm's outcomes. Such outcome can, according to Falk (2007), be defined in terms of marketable output (e.g. patents or products), commercial output (e.g. sales), or enhanced productivity and a better competitive position. Importantly, Nambisan and Baron (2013) identify a number of similar performance indicators at the level of the participating firms in discussing potential benefits from ecosystem participation. Subsequently, building on social exchange theory and in congruence with the literature on innovation ecosystems and organizational interdependence, we propose the following hypothesis:

H1: There is a positive relation between the level of organizational interdependence and output additionality obtained from innovation ecosystem participation

Furthermore, while Falk (2007) refers to output additionality as the ultimate goal, she also calls for a focus on the innovation process itself, and calls for an integration of behavioral additionality as an antecedent of output additionality. Indeed, as Georghiou (1997) points out, not only firm's performance has to be considered as the outcome, but firm's behavioral changes and the impact of such changes on the firm may also be considerable and therefore not to be neglected. Specifically, according to Falk (2007), the extent to which innovation support helps firms to accelerate their innovation speed and to build and extend networks and skills, is an antecedent of the overall outcomes that can be expected from such support. Along the same lines, Knockaert and Spithoven (2014) and Knockaert et al. (2014), respectively, consider acceleration and cognitive capacity additionalities in their studies on changes in firm behavior. As such, applying the relevance of behavioral additionality as an antecedent of output additionality to innovation ecosystems, we argue that firms that belong to such ecosystems are likely to change their behavior in terms of innovation speed, and to extend their network and skills bases. This is further in line with the ecosystem literature, suggesting that firms that collaborate in innovation ecosystems may experience benefits both in terms of innovation speed and cognitive capacity additionality. As to what the first benefit is concerned, Gawer and Cusumano (2014) explicitly point to the effects of innovation ecosystem participation in terms of reduced time to market. Furthermore, the innovation literature points to the importance of accessing and managing information and knowledge that are available external to the firm in order to advance innovation speed (Chesbrough 2003; Markman et al. 2005; Knockaert and Spithoven 2014). Similarly, Prahalad and Hamel (1990) point to collective learning as a determinant of innovation speed. The generation of such innovation speed may however require an intensive search process for collaboration partners, in which firms may need to invest considerable amount of time and money (Cohen and Levinthal 1990; Laursen and Salter 2006). In such circumstances, participation in an innovation ecosystem may facilitate the search and information access process, resulting in a higher innovation speed. Indeed, following social exchange theory, innovation ecosystem participants are likely to benefit from generalized reciprocity, in turn decreasing expenses and time lost due to conflicts and free rider behavior (Das and Teng 2002). With reference to the second benefit in terms of cognitive capacity additionality [uniting impact on both networks and skills (Knockaert et al. 2014)], several authors point to the advantages of leveraging complementary capabilities and other assets (van der Borgh et al. 2012; Nambisan and Baron 2013). Similarly, Moore (1993) points to an innovation ecosystem as a network of companies that coevolve capabilities around a shared set of technologies, knowledge, or skills. As such, it can be expected that output additionality generated by participating in an innovation ecosystem is realized through behavioral additionality, in which the behavior of the participating firm is permanently changed. As such, we offer the following hypothesis:

H2: Behavioral additionality mediates the relation between organizational interdependence and output additionality obtained from innovation ecosystem participation

2.3. Ecosystem board integration as a moderator in the organizational interdependence–ecosystem impact relationship

However, as we subsequently argue, the extent to which firms facing high levels of organizational interdependence benefit from innovation ecosystem participation will be contingent on the extent to which they integrate that ecosystem in the firm's (decision) structures. By internalizing the ecosystem, this participation becomes less noncommittal and is more likely to result in reciprocity, which is one of the base tenets of social exchange theory (Das and Teng 2002). In line with our research objectives, we explicitly aim at understanding how structures at top management level can help in strengthening innovation ecosystem impact. One of the most important decision-making bodies, or even the highest authority in firms, is the board of directors (Sundaramurthy and Lewis 2003). Within the board of directors, the appointment of outside directors[1] is typically considered a good practice to connect the firm to its environment. Particularly, as Zajac (1988) indicates that interlocking directorates are vehicles for inter-organizational coordination. Importantly, Westphal and Zajac (1997) indicate that in explaining board independence [or: the extent to which the (outside) board can function independently from the firm's management (Johnson et al.

2013)], social exchange theory is a particularly important paradigm. Specifically, as members from one organization engage in the board of directors of another organization, the principle of (generalized) reciprocity is likely to prevail. As such, as we argue, innovation ecosystem participation may be especially beneficial if important players in the ecosystem are also incorporated in the firm's board of directors as outside directors. This is because boards do not only engage in control tasks but also have an important role to play in enhancing the firm's reputation, establishing and opening networks, and strategic decision making, also referred to as the board's service role (Zahra and Pearce 1989; Minichilli et al. 2009). In a context of inter-organizational collaboration, the board of directors is seen as a unique formal mechanism to link top managers representing different institutions and an opportunity to exchange information and to observe diverse leadership styles and their consequences (Gulati and Westphal 1999). Indeed, board interlocks are frequently expected to facilitate social cohesion and the exchange of information between firms. Furthermore, the incorporation of outside directors may enhance trust in the firm (Westphal and Zajac 1997; Gulati and Westphal 1999; Cropanzano and Mitchell 2005). Importantly, as Sundaramurthy and Lewis (2003) indicate that trust facilitates collaboration and serves as a facilitator in social exchange.

By consequence, as to what the first part of the mediated relationship, namely the relationship between organizational interdependence and behavioral additionality is concerned, we argue that ecosystem board integration (i.e. the appointment of members from the innovation ecosystem to the firm's board of directors) will strengthen this relationship as such integration enforces reciprocity. Reciprocity is one of the basic tenets of social exchange theory (Cropanzano and Mitchell 2005) in which contingent interpersonal transactions take place. By incorporating external directors from the ecosystem, trust is enhanced, in turn resulting in the strengthening of reciprocity and the likelihood that the focal firm benefits from ecosystem participation and experiences behavioral additionality.

As to what the second part of the mediated relationship is concerned, we argue that the relationship between behavioral additionality and output additionality will be particularly strong if important actors in the ecosystem are incorporated in the board of directors as social exchange is optimized if the source of new knowledge is incorporated in the firm's structures. Particularly, through board interventions, board outsiders coming from the ecosystem can be instrumental in translating firms' behavioral change into concrete and measurable economic outputs. Subsequently, we offer the following hypothesis:

> *H3: Ecosystem board integration is a moderator in the H2-relationship such that it reinforces (a) the relationship between organizational interdependence and behavioral additionality and (b) the relationship between behavioral additionality and output additionality*

We graphically present our conceptual framework in Fig. 1.

3. Methodology

3.1. Data collection and sample description

Innovation ecosystems are particularly of relevance for firms engaging in innovation (Jackson 2011). Therefore, we deemed it particularly relevant to conduct our study in a sample of firms committed to innovation. We subsequently contacted TEKES, the national public policy agency for innovation in Finland, and received a list of all 5,886 firms that had applied for, but had not necessarily received, innovation financing from the agency between 2009 and 2013. Considering TEKES as a base for data collection is particularly relevant given our focus on innovation ecosystems and innovative firms that participate in these ecosystems. Indeed, TEKES is the only public innovation activity funder in Finland, engaging in resource provision for broad-based innovation activities including R&D and patent activities but also other innovation activities covering business models, marketing, and services. We collected survey data through telephone interviews with the CEOs of these innovative firms during the period September–October 2014. Contact information was missing for 777 of these firms, 876 telephone numbers were invalid, 939 firms did not answer the phone after multiple calls, and 95 companies had ceased to exist or were acquired by other firms, reducing our dataset to 3,198 firms. Eventually, 502 firms were willing to participate in the study (or: a response rate of 15.7%), resulting in 473 fully completed questionnaires. The survey used was first piloted in a random sample of 91 firms, leading to an adaptation in the formulation and changes in the interview design in order to reduce the maximum length of the telephone interview to 15 min. We used a staged interview technique, in which we first asked number of general questions on the firms (size, sector, team characteristics, stage of development, etc.), followed by the definition

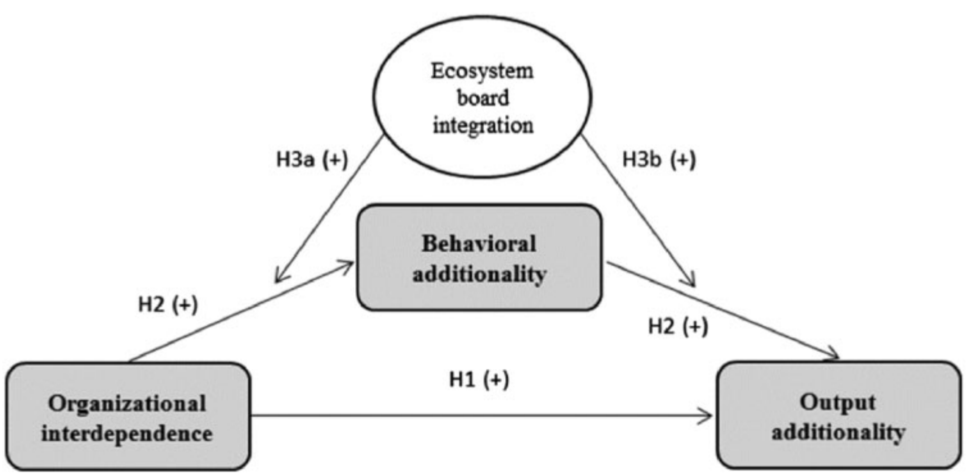

Figure 1. Conceptual model.

of an innovation ecosystem and the question on whether or not they belonged to an innovation ecosystem. In case they indicated to belong to an innovation ecosystem, they were asked to answer number of questions related to the most important innovation ecosystem they belonged to. In order to obtain additional key firm-level information (such as size and age), the survey data were subsequently merged with selected data from the global ORBIS database of Bureau Van Dijk.[2]

The 473 firms in our total sample have an average age of 12.3 years with a SD of 11.0. About 31% of these firms are active in manufacturing, 29% in IT, and 23% in services. On average, the firms employ 39 people (SD of 158). The average number of managers in the firms' Top Management Team (TMT) is 3.4 (SD of 1.6). The firms' board of directors have on average 3.5 board members (SD of 1.4) of which 2.2 (SD of 1.2) are inside board members.

3.2. Measures

3.2.1. Dependent and mediator variables

As articulated above, our study builds upon the additionality framework developed by Falk (2007). The measures developed within this framework are perceptual ones. We deemed the use of perceptual measures, as developed in the Falk framework and used in prior additionality studies, to be of particular relevance for our research question. Particularly, it may take a long time before benefits of ecosystem participation translate into objectively measurable performance changes such as growth in employment and sales, and innovation ecosystem effects may at that time be difficult to disentangle from other effects. Furthermore, by interviewing the CEO on his/her perception of innovation ecosystem impact, our information comes from the most knowledgeable individual in the organization, typically resulting in high levels of validity and reliability (Lyon et al. 2000). In what follows, we elaborate on the operationalization of the core variables used in the regression stage of our analyses.

Output additionality. In our operationalization of this variable, we sought to follow the theoretical conceptualization by Falk (2007), and to adhere to recent operationalizations of the construct, despite these comprising a wide range of measurements, often tailored to the specific measure or initiative assessed (Hsu et al. 2009). Specifically, as suggested by Falk (2007), our measurement unites marketable or commercial output alongside enhanced productivity and a better competitive position for the firm. Subsequently, this variable was measured using the following statements for which responses were recorded using a 7-point Likert scale ranging from 1 (totally disagree) to 7 (totally agree): (1) By belonging to this ecosystem, my company could enter new markets; (2) by belonging to this ecosystem, my company could increase its market share; (3) by belonging to this ecosystem, my company could engage in more ambitious projects. The average value for output additionality is 5.35. Cronbach α for the measure is 0.79.

Behavioral additionality. In measuring behavioral additionality, we again sought to reconcile Falk's theoretical conceptualization with the empirical operationalizations in the literature, which are diverse and tailor-made (Gök and Edler 2012). Specifically, the measure assessed the extent to which ecosystem participation resulted in changes in behavior in terms of (1) the firm's ability to innovate, (2) speed of progress, (3) the firm's skill base, and (4) firm networks. This is largely in line with Falk's framework in which behavioral additionality unites scope, cognitive capacity, acceleration, and scale additionalities and with prior studies on behavioral additionality, which have largely focused on cognitive capacity additionality (Hyvärinen 2009; Antonioli et al. 2014; Knockaert et al. 2014) and acceleration additionality (Knockaert and Spithoven 2014). Specifically, behavioral additionality was measured using the following statements for which responses were recorded using a 7-point Likert scale ranging from 1 (totally disagree) to 7 (totally agree): (1) by belonging to this ecosystem, my company was better able to innovate; (2) without belonging to this ecosystem, the progress of my company would have been slower; (3) without belonging to this ecosystem, my company would not have developed the same level of skills; and (4) without belonging to this ecosystem, the network of my company would be less extended. The average value for behavioral additionality is 5.42. Cronbach α for the measure is 0.80.

In order to test the distinctiveness of our additionality scales (i.e. the extent to which the respondents could discriminate between output additionality and behavioral additionality), we performed a confirmatory factor analysis. We compared a two-factor model where the two latent variables were allowed to correlate, with a one-factor model in which all eight items loaded on one latent variable. The results showed that the two-factor model [comparative fit index (CFI) = 0.97; root mean square of approximation (RMSEA) = 0.09 (90 percent confidence interval (CI): 0.058–0.117); standardized root mean residual (SRMR) = 0.04] fits the data better than the one-factor model [CFI = 0.92; RMSEA = 0.13 (CI: 0.104–0.158); SRMR = 0.06]. This indicates that respondents could distinguish between output and behavioral additionality.

3.2.2. Independent, moderator, and control variables

Organizational interdependence. In line with Das and Teng (2003) and Sambasivan et al. (2013), this main independent variable was assessed by asking respondents directly to assess 'the extent to which their company depends on (at least) one other firm in order to realize its company targets'. Responses were again recorded using a 7-point Likert scale ranging from 1 (not dependent at all) to 7 (totally dependent). The average value for organizational interdependence is 4.00.

Ecosystem board integration. This moderator variable was assessed by asking the respondents whether or not the board of directors hosts at least one member representing organizations from the most important innovation ecosystem the firm participates in. The variable takes the form of a dummy variable. Thirty-one percent of the respondents indicated that firms from the innovation ecosystem participate in their board of directors.

As control variables, we included a number of firm-level characteristics that are likely to affect the additionality generated from innovation ecosystem participation. We elaborate on these control variables in what follows.

Firm stage. We controlled for the stage of development (start-up, growth, maturity, or decline) a firm is in. This is in line with Kazanjian (1988), indicating that the challenges faced by firms are related to the firm's stage of development. As such, it is likely that additionality obtained from innovation ecosystem participation may also vary with the stage of development. Throughout the analyses, the maturity stage is used as the reference category. Firm stage was directly assessed by the respondents after offering them Kazanjian's (1988) definition for each stage.

Firm age. Information on firm age was obtained from the survey and verified with secondary data from ORBIS. We incorporate firm age as a control variable as prior additionality studies have controlled for age (e.g. Czarnitzki and Licht 2006; Hottenrott and Lopes-Bento 2014). Furthermore, as a firm's age affects the effectiveness with which a firm deploys its resources (Knockaert et al. 2014), its strategic decisions and performance (Henderson 1999), it is important to control for firm age.

Firm size. Firm size was controlled for by using the (log of) the revenues (in thousands) generated in 2013. This information was retrieved from the ORBIS database. We control for size as, in general, additionality studies control for firm size (Czarnitzki and Licht 2006; Hottenrott and Lopes-Bento 2014). Furthermore, Cassiman and Veugelers (2006) argue that firm size is an indispensable control variable in management and public policy research as many performance-related measures are contingent on size.

Firm sector. We controlled for the sector the firm is in as organizational practices, including the composition of the board, may be related to the industry (Eisenhardt 1988). We distinguish between firms in the manufacturing, ICT, and services sector, and use the category 'others' as the reference category.

CEO founder. We controlled for whether or not the interviewed CEO was also the founder of the company. We do so because founder-managed firms tend to behave differently from their non-CEO founder counterparts, for instance, in terms of risk orientation and financial performance (Jayaraman et al. 2000).

Patent dummy. As prior research indicates that R&D intensity may affect behavioral additionality (Cerulli et al. 2016), we deemed it necessary to control for it. Specifically, we constructed a patent dummy, based upon the patent data available in Orbis, taking a value of 1 in case the firm owns at least one patent and 0 otherwise.

3.3. Model specification

Given our focus on the relationship between organizational interdependence and different types of additionality from innovation ecosystem participation, we could only incorporate firms that indicated to be part of such an ecosystem. This is because firms that do not participate in an innovation ecosystem could naturally not respond to questions on the impact of ecosystem participation. In order to make sure that all respondents used the same interpretation of the term 'innovation ecosystem', we offered them the following definition (based on Nambisan and Baron 2013): 'Innovation ecosystems are characterized by (a) dependencies between the members, (b) common goals and objectives and (c) a shared set of knowledge and skills. In line with the definition of an innovation ecosystem, members can be firms but also other stakeholders such as universities, research institutes, financiers, community groups, standards setting organizations or professional associations'. Of the 473 firms in our sample, 312 (or 66%) indicated to participate in an innovation ecosystem, while 161 firms did not. Since respondents of firms not belonging to an innovation ecosystem were, naturally, not asked to respond to the questions on innovation ecosystem additionality, they got a score of zero for behavioral and output additionality. Simply eliminating the 161 firms that do not participate in any innovation ecosystem could, however, give rise to a sample selection problem as such elimination likely leads to a nonrandom subsample from a larger population of interest. In order to address this problem, we apply a Heckman two-stage selection model (Heckman 1979). This is necessary as our dependent variable Y (output additionality) is partitioned into observations that are >0 (Y_1) and equal to 0 (Y_2). The observations are defined as y_{1i} and y_{2i}. A restrictive form of the general model therefore is:

$$y_{2i} = \beta'_2 x_{2i} + \varepsilon_{2i},$$

$$y_{1i} = \beta'_1 x_{1i} + \varepsilon_{1i} \text{ if } y_{2i} > 0$$

where the error terms ε_{2i} and ε_{1i} have a zero mean with constant variance. While the parameter of interest (β_1) can be estimated using the second function above, the estimates are potentially biased because of the omitted-variable problem. Therefore, after specifying conditional density f (Y|X,β), the following equation can be derived using (Heckman 1979).

$$Y_i = \beta' X_i + \mu\lambda_i + \eta_i$$

where λ_i is referred to as the Mill's ratio and a monotone decreasing function of the probability that an observation is selected into the sample (Cader and Leatherman 2011).

Specifically, in the first stage of the Heckman selection model, also called the selection equation, we used a probit regression in order to determine which firms in our overall sample participated in an ecosystem. Particularly, we use three theoretically determined variables that affect selection but not the substantive problem of interest, as exclusion restrictions. Specifically, we argue that venture capital, whether or not the firm received public research support, and the size of the top management team will affect the likelihood of innovation ecosystem participation, but not the additionality received from innovation ecosystem participation. Indeed, extant literature found that as ventures become affiliated with (prominent) venture capitals (VCs), their likelihood of future alliance and network formation increases (Ozmel et al. 2013). Furthermore, larger top management teams are likely to have more extensive connections and relationships with potential partnering organizations than smaller ones, and therefore have a higher rate of alliance formation (Eisenhardt and Schoonhoven 1996). Finally, firms that receive financing from public support programs are found to be more successful in alliance/network formation (Nishimura and Okamuro 2011).

The selection equation took the following form: innovation ecosystem participation (0/1) = *F* (firm stage, firm age, firm size, sector, CEO founder, venture capital, TMT size, public research support). We define this dummy variable [ecosystem participation (0/1)] as a function of firm stage, firm sector, a VC dummy (indicating whether or not the firm received VC financing), TMT size, firm size (measured as the log of the revenues in thousands in 2013), and a public research support dummy (indicating whether or not the firm received public funding for research purposes). The results of this probit regression are reported in Table 1. Having received public research support ($B = 0.616$, $P < 0.001$) and the size of the firm's TMT ($B = 0.079$, $P < 0.1$) are positively related to the likelihood of innovation ecosystem participation.

Based upon the results of this first-stage model, we predicted and saved the value for the inverse Mill's ratio (λ_i), which is the monotone decreasing function of the probability that an observation is selected into our sample. In the second stage or regression equation, which estimates the model with the different additionality types as dependent variables, the inverse Mill's ratio enters as an explanatory variable. A statistically significant inverse Mill's ratio implies that its inclusion is crucial in order to avoid sample selection bias.

4. Results

4.1. Findings

Following the elaboration on the selection equation, we now turn to the discussion of our main results. Table 2 provides an overview of the means, standard deviations (S.D.) and correlations for all variables used in the regression equations.

To test the conceptual moderated mediation model presented in Fig. 1, we employed a regression-based path analysis by means of Hayes' process macro for SPSS (Hayes 2013). The variance inflation factors range between 1.021 and 2.250, which means that multicollinearity does not pose a problem. The Durbin Watson coefficients

Table 1. Selection equation

Part of an ecosystem (0/1)	Coefficient (SE)
(Constant)	0.181 (0.380)
Venture Capital	0.214 (0.176)
TMT size	0.079* (0.047)
Public research support receiver	0.616**** (0.153)
Firm stage: start	−0.175 (0.257)
Firm stage: grow	−0.229 (0.190)
Firm stage: decline	−0.538 (0.497)
Firm age	−0.008 (0.007)
Firm size	−0.001 (0.056)
Sector: manufacturing	−0.194 (0.212)
Sector: ICT	0.037 (0.208)
Sector: services	−0.009 (0.224)
CEO Founder	−0.078 (0.218)

Significance level: *P<0.10, **P<0.05, ***P<0.01, ****P<0.001; *n* =473.

range between 1.814 and 2.097, indicating that there is no autocorrelation problem.

Our conceptual model, depicted as a path model, is presented in Fig. 2. Specifically, in line with Hayes (2013), the model was divided into five sub models. Model 1 allows assessing the total relationship between organizational interdependence and output additionality (H1). Models 2 and 3 assess the indirect relationship between organizational interdependence and output additionality through behavioral additionality (H2). Finally, the moderating effect of ecosystem board integration is examined in Models 4 and 5 (for H3a and H3b, respectively).

Table 3 provides the results of our analysis.

First, we developed a control model, incorporating all control variables and the inverse Mill's ratio. This model was marginally statistically significant ($P < 0.10$), with the patent dummy having a significantly negative coefficient. Model 1 then reports the total effect (c) of organizational interdependence on output additionality, which is statistically significantly positive (c, $B = 0.144$, $P < 0.01$). As such, hypothesis 1 is confirmed. The size of the coefficient (c) indicates that an increase in the firm's organizational interdependency by 1 S.D. from the mean (or a 49% increase) is related to an increase in output additionality by 5.01%. Furthermore, Model 1 indicates that firms that own at least one patent experience lower levels of output additionality from innovation ecosystem participation compared with their counterparts who have not engaged in patenting. The total effect is then decomposed in a direct (c′) and indirect (a × b) effect in Models 2 and 3. Through these models, we find that firms in which the CEO is also the company founder experience higher levels of behavioral additionality. The ICT sector dummy variable is further negatively related to behavioral additionality, but positively to output additionality. The direct relationship between organizational interdependence and output additionality (c′) is positive, but only marginally significant ($P < 0.10$). Furthermore, there is a significantly positive relationship between organizational interdependence and behavioral additionality (a, $B = 0.113$, $P < 0.01$) and a significantly positive relation between behavioral additionality and output additionality (b, $B = 0.721$, $P < 0.001$). As such, the decomposition of the total effect into a direct and indirect effect takes the following form: $c = c' + a \times b$ (or: $0.1380 = 0.0563 + 0.1134 \times 0.7207$). It is further particularly through the addition of behavioral additionality in Model 3 that the model strength is significantly improved, pointing to the strong

Table 2. Means, SD, and correlations

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Firm stage: start	0.20	0.40	1														
firm stage: grow	0.60	0.49	−0.61*	1													
Firm stage: decline	0.01	0.11	−0.06	−0.14*	1												
Firm age	12.24	10.81	−0.25*	−0.09	0.06	1											
Firm size	2.72	1.29	−0.38*	0.11*	0.03	0.31*	1										
Sector: manufacturing	0.27	0.44	−0.02	−0.15*	0.02	0.27*	0.06	1									
Sector: ICT	0.33	0.47	0.05	0.08	0.00	−0.26*	−0.11	−0.43*	1								
Sector: services	0.23	0.42	−0.03	0.06	0.03	−0.07	−0.01	−0.33*	−0.38*	1							
CEO founder	0.86	0.35	0.10	0.15*	0.05	−0.25*	−0.21*	−0.08	0.14*	0.03	1						
Patent dummy	0.36	0.48	−0.02	−0.03	0.03	0.10	0.07	0.26*	−0.19*	−.05	−0.04	1					
Inverse Mills ratio	0.52	0.17	−0.13*	0.18*	0.16*	−0.07	−0.13*	0.05	0.08	−0.12*	0.04	−0.20*	1				
Organizational interdependence	4.00	1.96	0.01	−0.01	0.02	−0.06	−0.03	−0.02	−0.07	0.09	0.00	−0.06	−0.03	1			
Behavioral additionality	5.42	1.24	0.00	0.09	−0.06	−0.08	−0.08	0.02	−0.13*	0.07	0.13*	−0.01	−0.10	0.19*	1		
Ecosystem board integration	0.31	0.46	0.03	0.00	−0.08	−0.08	−0.05	0.04	0.04	−0.11	−0.02	−0.05	−0.15*	−0.02	0.04	1	
Output additionality	5.35	1.30	−0.01	0.08	0.00	−0.04	−0.09	−0.05	−0.04	0.11	0.11*	−0.11	0.01	0.22*	0.71*	0.02	1

Significance level: *P<0.05; *n*=312; correlations between dummy variables should be interpreted with care.

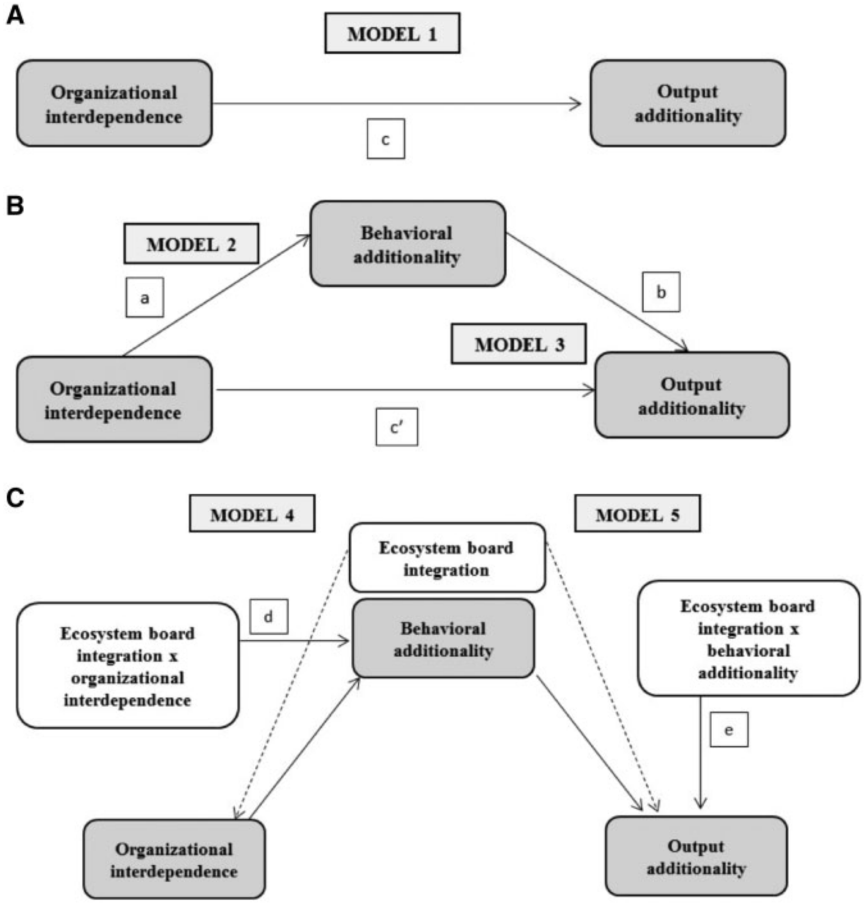

Figure 2. Conceptual model (Fig. 1) represented in the form of a path model, referring to OLS regression coefficients (Table 3).

relationship between behavioral and output additionality. In terms of economic significance, the size of coefficient (a) indicates that the firm's behavioral additionality indirectly increases by 4.09% when the firm's organizational interdependence increases by 1 S.D. from the mean. Similarly, the firms' output additionality increases by 16.78% when behavioral additionality increases by 23% [i.e. an increase from the mean to the mean plus 1 S.D. (coefficient b)]. The 95% confidence interval for this indirect effect, based on 10,000 bootstrap samples, is between 0.027 and 0.140. This indicates that behavioral additionality positively mediates the relationship between organizational interdependence and output additionality, hence, hypothesis 2 is supported. Next, we examine whether ecosystem board integration positively moderates the relationship between organizational interdependence and behavioral additionality (d, Model 4) and between behavioral additionality and output additionality (e, Model 5). The moderation effect is only significant in Model 5 ($B = 0.231$, $P < 0.05$), while statistically insignificant in Model 4 (in which the model strength also decreases compared with Model 2). As such, we find partial support for hypothesis 3, and more specifically for H3b. We plot the significant interaction effect in Fig. 3. Specifically, the figure indicates that when firms experience low levels of behavioral additionality from innovation ecosystem participation (mean − 1 S.D.), integrating board members from the ecosystem does not increase output additionality, but on the contrast, lowers it. However, when firms experience high levels of behavioral additionality from innovation ecosystem participation (mean + 1 SD), integrating board members from the ecosystem is related to higher levels of output additionality.

4.2. Robustness checks and *post hoc* analyses

In order to test the robustness of our findings and to provide more fine-grained insights into the results, we ran a number of additional analyses. First, in order to test the robustness of our findings, we reran our model using structural equation modeling (SEM) analysis by means of the R package Lavaan. In line with the expectations articulated in Hayes et al. (2017), the results remain substantively identical. Indeed, while the coefficients are the same, there are small differences in the standard errors, as the two techniques use different statistical theories and rely on different assumptions. Complementary to PROCESS, SEM provides the P-value of the indirect effect of organizational interdependence on output additionality through behavioral additionality, which is 0.003, in line with the 95% confidence interval for the indirect effect in the PROCESS method.

Second, our measure of behavioral additionality united, in line with Falk (2007), items related to the impact on innovation capabilities, skills, speed of progress, and firm networking. While these items are typically considered to constitute behavioral additionality, we deemed it relevant to consider the different items separately and to run analyses with each of these items as mediator (instead of behavioral additionality) in our models. We find that the mediated

Table 3. Results of the moderated mediation analyses

Regression models with process macro (Hayes, 2013)

	Control model Output additionality	Model 1 Output additionality	Model 2 Behavioral additionality	Model 3 Output additionality	Model 4 Behavioral additionality	Model 5 Output additionality
(Constant)	5.118**** (.461)	4.603**** (0.519)	5.407**** (0.493)	0.706 (0.467)	5.409**** (0.584)	0.834 (0.532)
Firm stage: start	0.164 (.283)	0.176 (0.294)	0.063 (0.279)	0.131 (0.215)	−0.017 (0.300)	0.042 (0.222)
Firm stage: grow	0.345 (.212)	0.314 (0.227)	0.271 (0.216)	0.119 (0.166)	0.326 (0.234)	−0.017 (0.175)
Firm stage: decline	0.362 (0.694)	0.128 (0.683)	−0.485 (0.649)	0.478 (0.499)	−0.173 (0.746)	0.121 (0.554)
Firm age	0.002 (0.008)	0.008 (0.009)	−0.005 (0.008)	0.011* (0.006)	−0.006 (0.009)	0.010 (0.007)
Firm size	−0.082 (0.060)	−0.079 (0.060)	−0.051 (0.057)	−0.042 (0.043)	−0.076 (0.072)	−0.024 (0.054)
Sector: manufacturing	0.105 (0.239)	0.098 (0.252)	−0.074 (0.240)	0.152 (0.184)	−0.008 (0.258)	−0.003 (0.191)
Sector: ICT	−0.073 (0.238)	−0.013 (0.243)	−0.538** (0.231)	0.375** (0.179)	−0.497** (0.247)	0.272 (0.185)
Sector: services	0.325 (0.247)	0.306 (0.256)	−0.217 (0.243)	0.463** (0.187)	−0.169 (0.265)	0.316 (0.197)
CEO Founder	0.357 (0.232)	0.295 (0.246)	0.532** (0.233)	−0.088 (0.181)	0.409 (0.252)	0.031 (0.188)
Patent dummy	−0.363** (0.168)	−0.350** (0.178)	−0.177 (0.169)	−0.223* (0.130)	−0.175 (0.183)	−0.192 (0.136)
Inverse Mills ratio	−0.279 (0.481)	−0.295 (0.505)	−1.078* (0.480)	0.482 (0.373)	−0.999* (0.529)	0.720* (0.399)
Organizational interdependence		0.138*** (0.041) [c]	0.113*** (0.039) [a]	0.056* (0.031) [c′]	0.127** (0.051)	0.066* (0.032)
Behavioral additionality				0.721**** (0.050) [b]		0.682**** (0.059)
Ecosystem board integration					0.326 (0.428)	−1.215* (0.619)
Ecosystem board integration × organizational interdependence					−0.072 (0.096) [d]	
Ecosystem board integration × behavioral additionality						[e] 0.231** (0.111)
F-value	1.629*	2.169*	2.743**	19.467***	1.885*	17.396***
Adjusted R^2	0.024	0.054	0.079	0.496	0.052	0.522
R^2	0.062	0.101	0.124	0.523	0.111	0.554

Significance level: *P<0.10, **P<0.05, ***P<0.01, ****P<0.001; *n* =312; unstandardized coefficients are reported (standard errors between brackets).

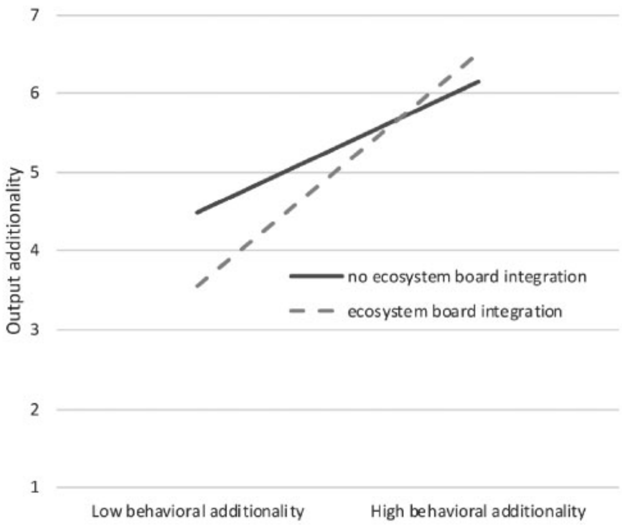

Figure 3. Moderation effect of ecosystem board integration on the relationship between behavioral and output additionality.

relationship which arose from our Models 2 and 3 holds for each of the models in which behavioral additionality is substituted by the single item related to a specific change in behavior. Third, whether or not firms are subsidiaries of other firms, or belong to a group of firms, may affect the perceived impact from innovation ecosystem participation. Therefore, we verified whether or not >50% of the shares of the firms in our dataset belonged to another firm. This data were available in ORBIS for about 70% of the firms in our sample. Interestingly, our findings show that firms of which <50% of the shares are held by another firm experience higher levels of output additionality from innovation ecosystem participation. Furthermore, all findings reported on earlier remained stable. Fourth, while we particularly focused on characteristics and related variables fitting the theoretical perspectives selected for this study, we deemed it important to assess whether additional factors could affect the impact of innovation ecosystems, and as such add further richness to our findings. As we ran additional analyses incorporating the other variables collected in this study, we found interesting findings related to ecosystem stage. Particularly, we asked the respondents to assess the stage of the ecosystem they participated in, which could be starting, growing, maturing, or declining. Our additional analyses showed that ecosystem stage was an important moderator for Model 4, indicating that the relationship between organizational interdependence and behavioral additionality is particularly strong when firms are participating in starting or growing ecosystems. We provide more details on the results of robustness checks 2, 3, and 4 in Appendix Table A1.

5. Discussion

This study aimed at disentangling the circumstances under which firms benefit from innovation ecosystem participation. In doing so, in contrast to prior innovation ecosystem research, we do not focus on the role of the hub or the ecosystem orchestrator, but study the impact achieved by the 'average' innovation ecosystem participant. In line with our theoretical reasoning, we find that there is a positive relationship between the firm's level of organizational interdependence and output additionality generated from innovation ecosystem participation, and that this relationship is mediated by behavioral additionality. By consequence, our results indicate that when firms participate in innovation ecosystems, they are likely to change their behavior in terms of speed, skills, and networks, which is subsequently related to stronger firm-level outputs, especially in firms facing higher levels of organizational interdependence. Furthermore, we find that the relationship between behavioral additionality and output additionality is particularly strong in case the innovation ecosystem is internalized in the firm's structures, more specifically by appointing innovation ecosystem members to the board of directors. As we theorized, this can be explained from a social exchange perspective, in which such internalization is related to higher levels of trust and subsequent more efficient information exchange leading to higher impact levels. In what follows, we elaborate on the contributions of our study for academia and practitioners. Finally, we discuss the limitations of our study just as the directions for future research.

5.1. Contributions to the Literature

Our article contributes to the field of innovation studies, and more particularly the innovation ecosystem literature, just as to the corporate governance literature. First, our article responds to a gap in the additionality literature, which has typically focused on one type of additionality at the time, as such neglecting to provide insights into a range of additionality effects (Cerulli et al. 2016; Czarnitzki and Delanote, 2017). Second, as to what the ecosystem literature is concerned, this study is one of the first ones to directly study the extent to which firms benefit from innovation ecosystem participation. As such, it contributes to the innovation ecosystem literature by complementing insights from specific case studies of large players through a study of innovation ecosystem impact with a broad-based sample of almost 500 innovative firms from different sizes and sectors. Indeed, so far, the literature has mainly considered the role of orchestrators, hubs, and platform leaders (e.g. Iansiti and Levien 2004; Gawer and Cusumano 2014) in innovation ecosystems, often through the lens of the ICT industry (West and Wood 2013; Gawer and Cusumano 2014). By consequence, this work constitutes a first empirical attempt to analyze the impact of innovation ecosystems on innovative firms across an entire economy, irrespective of the sector the firm is in. Indeed, while many researchers have pointed to the potential benefits of such participation in terms of branding and reputation advantages (van der Borgh et al. 2012), risk reduction (Li and Garnsey 2014), cost reduction (Gawer and Cusumano 2014), access to common resources such as networks (Clarysse et al. 2014), cross-industrial complementarities (van der Borgh et al. 2012), complementary innovations, reduced time to market (Gawer and Cusumano 2014), easy access to established markets, and better IPO opportunities (Eisenmann et al. 2009; Ceccagnoli et al. 2012), to date, no studies have assessed whether benefits from innovation ecosystem participation also occur. Our study then contributes to the ecosystem literature by providing theoretical and empirical insights into the innovation ecosystem's value added, hereby offering a rare economy-wide perspective covering all industries, firm sizes, and firm ages. Furthermore, it contributes to the emerging field of innovation ecosystem studies by indicating when firms are more or less likely to benefit from innovation ecosystem participation, pointing to how innovation mechanisms could help firms to manage their organizational interdependencies. Considered more broadly, by focusing explicitly on innovation ecosystems, our study complements work that has taken the collaboration with external partners as a prerequisite for successful innovation, such as work on industrial districts, clusters, business ecosystems, networks of innovation

(Ferrary and Granovetter 2009), industrial relations (Piore 2011), and high tech clusters (Sable 2007).

Third, it contributes to the corporate governance literature which has extensively depicted the addition of firm stakeholders on the board of directors as a best practice (Moriarty 2014). However, in doing so, it has studied the implications of stakeholder representation on the board in particular circumstances, and in specific firms, such as, for instance, social enterprises (Spear et al. 2009) or academic spin-out firms (Bjornali and Gulbrandsen 2010). Our study contributes to this literature by studying firms that engage in innovation in general, and by considering a specific type of stakeholders as potential board members, namely those that operate in the firm's environment and belong to its innovation ecosystem. Furthermore, this study contributes to research at the cross borders of corporate governance and innovation, and which has, for instance, studied the relationship between board interlocks and R&D alliances (Sullivan and Tang 2013), but which has so far neglected to consider innovation ecosystems as a relatively new form of interfirm collaborations.

5.2. Implications for practice

Our study also has implications for practitioners, such as CEOs, innovation managers, and policy makers. Specifically, for CEOs and innovation managers, our study provides insights into the circumstances under which firms benefit from innovation ecosystem participation. Particularly, firms that are relatively independent in terms of ownership (i.e. for which <50% of the shares are held by another firm), and which face relatively high levels of organizational interdependence tend to benefit from innovation ecosystem participation. Furthermore, our study points to the importance of carefully selecting outside board members, and considering the inclusion of board members from the innovation ecosystem. Our findings are further relevant for public policy makers who have recently shown considerable interest in the relationship between innovation ecosystems and regional and national competitiveness and who are eager to learn how they could contribute to the emergence and functioning of such innovation ecosystems (Li and Garnsey 2014; Oh et al. 2016). For instance, it shows the relevance of considering the extension of support to innovation ecosystems beyond those in ICT, as firms seem to realize similar benefits from innovation ecosystem participation, irrespective of their age, size, or sectoral activity. Furthermore, it points to the relevance of the establishment of pools of outside board members (a process that has been recently initiated in a number of countries including the UK and Belgium), and in doing so, considering innovation ecosystem co-players as potential outside board members.

5.3. Limitations and directions for future research

Despite these contributions and implications, our study also has some limitations, pointing to future research directions. First, we carried out our research in a particular context, namely that of Finland. While such a focus is warranted for reasons of homogeneity, it may limit the generalizability of our findings. At the same time, we are confident that the results of our Finnish study are relevant to other small open economies that are innovation leaders and for other economies at the forefront of innovation. At the same time, we hope to see empirical broad-based evidence from other countries that could shed light on the role of innovation ecosystems in different institutional settings. Second, our study was cross-sectional in nature, which is refraining us from detecting causal relationships. While it is, following the literature on additionality, quite natural for behavioral additionality to be an antecedent of output additionality, longitudinal studies could assess to which extent the relationship between the two types of additionality is unidirectional. Along the same lines, our research design does not allow for solving potential endogeneity issues in our data. Future research designs could consider the inclusion of instrumental variables (see e.g. Bascle, 2008) and employ two-stage least squares regression analyses in order to alleviate these concerns. Furthermore, following the wide range of sectors and activities the firms in our sample engage in, and given our strive to reconcile Falk's theoretical conceptualizations of additionality with recent empirical operationalizations of the concept in our work, our results do not provide detailed insights into changes in behavior directly related to the innovation process nor specific (innovation) outputs, which may be more directly related to firm strategies and objectives. Future research could purposefully assess how innovation ecosystem participation affects the innovation process. In order to do so, an in depth case study design may be the most instrumental. Such a design could then unite firms incorporated in an innovation ecosystem and firms outside of such an ecosystem which could be followed longitudinally through specific inventions or innovative developments, with the involved researchers combining archival data, interviews with the main actors, alongside observational designs. Third, in assessing the contingencies under which innovation ecosystem benefits are increased, we explicitly chose to focus on structures at the top management team level. Future research could also purposefully assess how the creation of social sanctions, an enforced generalized reciprocity or a macro-culture [in line with social exchange theory (Das and Teng 2002)] can be developed to the benefit of the entire innovation ecosystem. Furthermore, it could assess the impact of changes incorporated at other levels of the firm, for instance, through the exchange of (R&D) personnel or the implementation of coordination mechanisms (e.g. through liaison officers). Fourth, while we do find that appointing members from the innovation ecosystem to the board of directors is beneficial to the firm, future research could purposefully continue to disentangle the impact of board interlocks in the context of innovation ecosystems. For instance, the extent to which board members from the innovation ecosystem contribute may be contingent on other factors, such as the characteristics of the representatives themselves (e.g. human and social capital), the nature of the firm they represent (e.g. size, age, position in the innovation ecosystem), and the nature of the relationship between the firms in the ecosystem (e.g. interaction patterns, type of collaborations). Finally, our study aimed at disentangling the relationship between firm-level characteristics and firm-level benefits from participation in an innovation ecosystem. Future research (for instance using multi-level research designs) could purposefully assess under which firm-level and ecosystem-level circumstances, or combinations of both, innovation ecosystem impact is optimized.

6. Conclusion

Our study aimed at contributing to the innovation literature in general, and innovation ecosystem literature specifically, by shedding light on the circumstances under which innovation ecosystem participation is beneficial to the firm. In doing so, we built upon social exchange theory. Our findings indicate that organizational interdependence is strongly related to behavioral and output additionality obtained through innovation ecosystem participation. Behavioral additionality is further particularly likely to translate into output additionality if the firm appoints external board members belonging to the innovation ecosystem. Next to the contributions to the literature and implications for practice, our study points to a number of interesting future research areas, including the administration of longitudinal research designs or the disentanglement of factors at innovation ecosystem or firm level (e.g. position of the firm in the innovation ecosystem, integration mechanisms between ecosystem collaborators,...), potentially affecting ecosystem impact.

Notes

1. Outside directors (or: outsiders) are individuals who are not part of the TMT, its associates or families, not employees of the firm or its subsidiaries, and not members of the immediate past top management group (Pearce and Zahra 1991).
2. For more information about the Orbis database, see http://www.bvdinfo.com/en-gb/our-products/company-information/international-products/orbis

Acknowledgements

This analysis is based on the research cooperation between VTT Technical Research Centre Finland Ltd., Ghent University (Belgium) and Science and Technology Policy Institute (STEPI), South Korea) and is part of the EnterGROW project (Number 40349/13) financed by TEKES - the Finnish Funding Agency for Innovation - and VTT. The authors would like to thank the participants of the Babson Entrepreneurship Research Conference 2016 (Bodo, Norway) and colleagues from the department of Innovation, Entrepreneurship and Service management (Ghent University) and VTT Finland for their feedback and suggestions.

8. References

Adner, R. (2006) 'Match your Innovation Strategy to your Innovation Ecosystem', *Harvard Business Review*, 84/4: 98–107.

—— and Kapoor, R. (2010) 'Value Creation in Innovation Ecosystems: How the Structure of Technological Interdependence Affects Firm Performance in Technology Generations', *Strategic Management Journal*, 31/3: 306–33.

Aerts, K. and Schmidt, T. (2008) 'Two for the Price of One?: Additionality Effects of R&D Subsidies: a Comparison Between Flanders and Germany', *Research Policy*, 37/5: 806–22.

Aiken, M. and Hage, J. (1968) 'Organizational Interdependence and Intra-organizational Structure', *American Sociological Review*, 33/6: 912–30.

Antonioli, D., Marzucchi, A., and Montresor, S. (2014) 'Regional Innovation Policy and Innovative Behaviour: Looking for Additionality Effects', *European Planning Studies*, 22/1: 64–83.

Autio, E. and Thomas, L. (2013) 'Innovation Ecosystems – Implications for Innovation Management?'. In: M. Dodgson, D. Gann, and N. Phillips (eds) *The Oxford Handbook of Innovation Management*, pp. 204–288. Oxford: Oxford University Press.

Bascle, G. (2008) 'Controlling for Endogeneity with Instrumental Variables in Strategic Management Research', *Strategic Organisation*, 6/3: 285–327.

Bjornali, E. S. and Gulbrandsen, M. (2010) 'Exploring Board Formation and Evolution of Board Composition in Academic Spin-offs', *Journal of Technology Transfer*, 35/1: 92–112.

Blau, P. M. (1964) *Exchange and Power in Social Life*. New Brunswick: Transaction Publishers.

Cader, H. and Leatherman, J. (2011) 'Small Business Survival and Sample Selection Bias', *Small Business Economics*, 37: 155–65.

Cassiman, B. and Veugelers, R. (2006) 'In Search of Complementarity in Innovation Strategy: Internal R&D and External Knowledge Acquisition', *Management Science*, 52/1: 68–82.

Ceccagnoli, M., Forman, C., Huang, P. et al. (2012) 'Co-creation of Value in a Platform Ecosystem: The Case of Enterprise Software', *MIS Quarterly*, 36/1: 263–90.

Cerulli, G., Gabriele, R., and Poti, B. (2016) 'The Role of Firm R&D Effort and Collaboration as Mediating Drivers of Innovation Policy Effectiveness', *Industry and Innovation*, 23/5: 426–47.

Chen, M. J. and Miller, D. (2012) 'Competitive Dynamics: Themes, Trends, and a Prospective Research Platform', *The Academy of Management Annals*, 6/1: 135–210.

Chesbrough, H. (2003) 'The Era of Open Innovation', *MIT Sloan Management Review*, 44/3: 35–41.

Clarysse, B., Wright, M., Bruneel, J. et al. (2014) 'Creating Value in Ecosystems: Crossing the Chasm Between Knowledge and Business Ecosystems', *Research Policy*, 43/7: 1164–76.

——, ——, and Mustar, P. (2009) 'Behavioural Additionality of R&D Subsidies: a Learning Perspective', *Research Policy*, 38/10: 1517–33.

Cohen, W. M. and Levinthal, D. A. (1990) 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly*, 35/1: 128–52.

Coombs, R., Harvey, M., and Tether, B. S. (2003) 'Analysing Distributed Processes of Provision and Innovation', *Industrial and Corporate Change*, 12: 1125–55.

Cropanzano, R. and Mitchell, M. S. (2005) 'Social Exchange Theory: An Interdisciplinary Review', *Journal of Management*, 31/6: 874–900.

——, Anthony, E., Daniels, S. et al. (2017) 'Social Exchange Theory: a Critical Review with Theoretical Remedies', *Academy of Management Annals*, 11/1: 476–516.

Cusumano, M. A. and Gawer, A. (2002) 'The Elements of Platform Leadership', *MIT Sloan Management Review*, 43/3: 51.

Cyert, R. M. and March, J. G. (1963) *A Behavioral Theory of the Firm*. Englewood Cliffs: Prentice Hall.

Czarnitzki, D. and Licht, G. (2006) 'Additionality of Public R&D Grants in a Transition Economy', *Economics of Transition*, 14/1: 101–31.

—— and Delanote, J. (2017) 'Incorporating Innovation Subsidies in the CDM Framework: Empirical Evidence from Belgium', *Economics of Innovation and New Technology*, 26 /1–2: 78–92.

Das, T. and Teng, B. (2002) 'Alliance Constellations: a Social Exchange Perspective', *Academy of Management Review*, 27/3: 445–56.

—— and —— (2003) 'Partner Analysis and Alliance Performance', *Scandinavian Journal of Management*, 19/3: 279–308.

Dedehayir, O. and Mäkinen, S. J. (2011) 'Measuring Industry Clockspeed in the Systemic Industry Context', *Technovation*, 31/12: 627–37.

De Man, A. P. and Duysters, G. (2005) 'Collaboration and Innovation: a Review of the Effects of Mergers, Acquisitions and Alliances on Innovation', *Technovation*, 25/12: 1377–87.

Eisenhardt, K. M. (1988) 'Agency-and Institutional-theory Explanations: The Case of Retail Sales COMPENSATION', *Academy of Management Journal*, 31/3: 488–511.

—— and Schoonhoven, C. B. (1996) 'Resource-based View of Strategic Alliance Formation: Strategic and Social Effects in Entrepreneurial Firms', *Organization Science*, 7/2: 136–50.

Eisenmann, T. R., Parker, G., and Van Alstyne, M. W. (2009) 'Opening Platforms: How, When and Why?' In: A Gawer (ed.) *Platforms, Markets and Innovation*, pp. 131–162. Northampton, MA: Edward Elgar.

Emerson, R. M. (1976) 'Social Exchange Theory', *Annual Review of Sociology*, 2: 335–62.

Falk, R. (2007) 'Measuring the Effects of Public Support Schemes on Firms' Innovation Activities: Survey Evidence From Austria', *Research Policy*, 36: 665–79.

Ferrary, M. and Granovetter, M. (2009) 'The Role of Venture Capital Firms in Silicon Valley's Complex Innovation Network', *Economy and Society*, 38/2: 326–59.

Foa, U. and Foa, E. (1980) 'Resource Theory: Interpersonal Behavior as Exchange'. In: K. Gergen, M. Greenberg, and R. Willis (eds) *Social Exchange: Advances in Theory and Research*, pp. 77–94. New York: Plenum.

Gawer, A. and Cusumano, M. A. (2014) 'Industry Platforms and Ecosystem Innovation', *Journal of Product Innovation Management*, 31/3: 417–33.

Georghiou, L. (1997) 'Issues in the Evaluation of Innovation and Technology Policy'. In: OECD (ed.) *Policy Evaluation in Innovation and Technology: Towards Best Practice*. Paris: OECD.

Gök, A. and Edler, J. (2012) 'The Use of Behavioural Additionality Evaluation in Innovation Policy Making', *Research Evaluation*, 21: 306–18.

Gnyawali, D. R. and Park, B. J. R. (2009) 'Co-opetition and Technological Innovation in Small and Medium-sized Enterprises: A Multilevel Conceptual Model', *Journal of Small Business Management*, 47/3: 308–30.

Gulati, R. and Gargiulo, M. (1999) 'Where do Interorganizational Networks Come From? ', *American Journal of Sociology*, 104/5: 1439–93.

—— and Westphal, J. (1999) 'Cooperative or Controlling? The Effects of CEO-board Relations and the Content of Interlocks on the Formation of Joint Ventures', *Administrative Science Quarterly*, 44/3: 473–506.

Gulbrandsen, M. and Rasmussen, E. (2012) 'The Use and Development of Indicators for the Commercialization of University Research in a National Support Programme', *Technology Analysis and Strategic Management*, 24/5: 481–95.

Hayes, A. F. (2013) *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-based Approach*. New York: Guilford Press.

Hayes, A., Montoya, A., and Rockwood, N. (2017) 'The Analysis of Mechanisms and Their Contingencies: PROCESS versus Structural Equation Modeling', *Australasian Marketing Journal*, 25/1: 76–81.

Heckman, J. J. (1979) 'Sample Selection Bias as a Specification Error', *Econometrica*, 47: 153–61.

Henderson, A. D. (1999) 'Firm Strategy and Age Dependence: A Contingent View of the Liabilities of Newness, Adolescence, and Obsolescence', *Administrative Science Quarterly*, 44/2: 281–314.

Herrera, L. and Sanchez, G. G. (2013) 'Firm Size and Innovation Policy', *International Small Business Journal*, 31/2: 137–55.

Homans, C. G. (1958) 'Social Behavior as Exchange', *American Journal of Sociology*, 62: 597–606.

Hottenrott, H. and Lopes-Bento, C. (2014) '(International) R&D Collaboration and SMEs: The Effectiveness of Targeted Public R&D Support Schemes', *Research Policy*, 43/6: 1055–66.

Hsu, F. M., Horng, D. J., and Hsueh, C. C. (2009) 'The Effect of Government-sponsored R&D Programmes on Additionality in Recipient Firms in Taiwan', *Technovation*, 29: 204–17.

Hyrynsalmi, S., Seppänen, M., Nokkala, T. et al. (2015) "Wealthy, Healthy and/or Happy—What Does 'Ecosystem Health' Stand For?". Paper presented at the *6th International Conference on Software Business*, Braga, Portugal, 10–12 June 2015, pp. 272–287. Springer Verlag.

Hyvärinen, J. (2009) 'Evaluation of Tekes Funding for Research Institutes and Universities—the Role of Talent', *Research Evaluation*, 18/5: 365–73.

Iansiti, M. and Levien, R. (2004) 'Strategy as Ecology', *Harvard Business Review*, 82/3: 68–81.

Isckia, T. (2009) 'Amazon's Evolving Ecosystem: A Cyber-bookstore and Application Service Provider', *Canadian Journal of Administrative Sciences*, 26/4: 332–43.

Iyer, B. and Davenport, T. H. (2008) 'Reverse Engineering: Google's Innovation Machine', *Harvard Business Review*, 86/4: 58–68.

Jackson, B. (2011) *What is an Innovation Ecosystem*? Washington DC. http://erc-assoc.org.

Jayaraman, N., Khorana, A., Nelling, E. et al. (2000) 'CEO Founder Status and Firm Financial Performance', *Strategic Management Journal*, 21/12: 1215–24.

Järvi, K. and Kortelainen, S. (2016) 'Taking Stock of Empirical Research on Business Ecosystems: a Literature Review', *International Journal of Business and Systems Research*, 11/3: 215–28.

Johnson, S., Schnatterly, K., and Hill, A. (2013) 'Board Composition Beyond Independence: Social Capital, Human Capital, and Demographics', *Journal of Management*, 39/1: 232–62.

Katz, D. and Kahn, R. L. (1966) *The Social Psychology of Organizations*. Hoboken: John Wiley & Sons Inc.

Kazanjian, R. K. (1988) 'Relation of Dominant Problems to Stages of Growth in Technology-based New Ventures', *Academy of Management Journal*, 31/2: 257–79.

Knockaert, M. and Spithoven, A. (2014) 'Under Which Conditions do Technology Intermediaries Enhance Firms' Innovation Speed? The Case of Belgium's Collective Research Centres', *Regional Studies*, 48/8: 1391–403.

——, ——, and Clarysse, B. (2014) 'The Impact of Technology Intermediaries on Firm Cognitive Capacity Additionality', *Technological Forecasting and Social Change*, 81: 376–87.

Laursen, K. and Salter, A. (2006) 'Open for Innovation: the Role of Openness in Explaining Innovation Performance Among UK Manufacturing Firms', *Strategic Management Journal*, 27/2: 131–50.

Li, Y. R. (2009) 'The Technological Roadmap of Cisco's Business Ecosystem', *Technovation*, 29/5: 379–86.

Li, J. F. and Garnsey, E. (2013) 'Building Joint Value: Ecosystem Support for Global Health Innovations', *Collaboration and Competition in Business Ecosystems. Advances in Strategic Management*, 30: 69–96.

—— and —— (2014) 'Policy-driven Ecosystems for New Vaccine Development', *Technovation*, 34/12: 762–72.

Luukkonen, L. (2000) 'Additionality of EU Framework Programmes', *Research Policy*, 29/6: 711–24.

Lyon, D. W., Lumpkin, G. T., and Dess, G. G. (2000) 'Enhancing Entrepreneurial Orientation Research: Operationalizing and Measuring a Key Strategic Decision Making Process', *Journal of Management*, 26: 1055–85.

Markman, G., Gianiodis, P., Phan, P. et al. (2005) 'Innovation Speed: Transferring University Technology to Market', *Research Policy*, 34: 1958–075.

Minichilli, A., Zattoni, A., and Zona, F. (2009) 'Making Boards Effective: an Empirical Examination of Board Task Performance', *British Journal of Management*, 20: 55–74.

Moore, J. (1993) 'Predators and Prey: the New Ecology of Competition', *Harvard Business Review*, 71/3: 75–83.

Moriarty, J. (2014) 'The Connection Between Stakeholder Theory and Stakeholder Democracy: an Excavation and Defense', *Business & Society*, 53/6: 820–52.

Nambisan, S. and Baron, R. (2013) 'Entrepreneurship in Innovation Ecosystems: Entrepreneurs' Self-regulatory Processes and Their Implications for New Venture Success', *Entrepreneurship Theory and Practice*, 37/5: 1071–97.

Narasimhan, R., Nair, A., Griffith, D. et al. (2009) 'Lock-in Situations in Supply Chains: a Social Exchange Theoretic Study of Sourcing Arrangements in Buyer-supplier Relationships', *Journal of Operations Management*, 27: 374–89.

Nishimura, J. and Okamuro, H. (2011) 'Subsidy and Networking: The Effects of Direct and Indirect Support Programs of the Cluster Policy', *Research Policy*, 40/5: 714–27.

Oh, D. S., Phillips, F., Park, S. et al. (2016) 'Innovation Ecosystems: A Critical Examination', *Technovation*, 54: 1–6.

Ozmel, U., Reuer, J. J., and Gulati, R. (2013) 'Signals Across Multiple Networks: How Venture Capital and Alliance Networks Affect Interorganizational Collaboration', *Academy of Management Journal*, 56/3: 852–66.

Pearce, J. A. and Zahra, S. A. (1991) 'The Relative Power of CEOs and Boards of Directors: Associations with Corporate Performance', *Strategic Management Journal*, 12/2: 135–53.

Pfeffer, J. (1972) 'Merger as a Response to Organizational Interdependence', *Administrative Science Quarterly*, 17/3: 382–94.

—— and Nowak, P. (1976) 'Joint Ventures and Interorganizational Interdependence', *Administrative Science Quarterly*, 21/3: 398–418.

—— and Salancik, G. R. (1978) *The External Control of Organizations: A Resource Dependence Approach*. New York: Harper and Row Publishers.

Piore, M. (2011) 'Whither Industrial Relations: Does it Have a Future in Post-industrial Society? ', *British Journal of Industrial Relations*, 49/4: 792–801.

Prahalad, C. and Hamel, G. (1990) 'The Core Competence of the Corporation', *Harvard Business Review*, 68/3: 79–91.

Sable, M. (2007) 'The Impact of the Biotechnology Industry on Local Economic Development in Boston and San Diego Metropolitan Areas', *Technological Forecasting and Social Change*, 74/1: 36–60.

Sambasivan, M., Siew-Phaik, L., Mohamed, Z. et al. (2013) 'Factors Influencing Strategic Alliance Outcomes in a Manufacturing Supply Chain: Role of Alliance Motives, Interdependence, Asset Specificity and Relational Capital', *International Journal of Production Economics*, 141/1: 339–51.

Seppälä, T. and Kenney, M. (2012) *Competitive Dynamics, IP Litigation and Acquisitions – The Struggle for Positional Advantage in the Emerging Mobile Internet*. Report, ETLA Discussion Papers, The Research Institute of the Finnish Economy, Finland, October.

Spear, R., Cornforth, C., and Aiken, M. (2009) 'The Governance Challenges of Social Enterprises: Evidence from a UK Empirical Study', *Annals of Public and Cooperative Economics*, 80/2: 247–73.

Sullivan, B. and Tang, Y. (2013) 'Which Signal to Rely on? The Impact of the Quality of Board Interlocks and Inventive Capabilities on Research and Development Alliance Formation Under Uncertainty', *Strategic Organization*, 11/4: 364–88.

Sundaramurthy, C. and Lewis, M. (2003) 'Control and Collaboration: Paradoxes of Governance', *Academy of Management Review*, 28/3: 397–415.

Tencati, A. and Zsolnai, L. (2009) 'The Collaborative Enterprise', *Journal of Business Ethics*, 85/3: 367–76.

Teirlinck, P. and Spithoven, A. (2012) 'Fostering Industry-science Cooperation Through Public Funding: Differences Between Universities and Public Research Centres', *Journal of Technology Transfer*, 37/5: 676–95.

Thompson, J. D. and McEwen, W. J. (1958) 'Organizational Goals and Environment: Goal-setting as an Interaction Process', *American Sociological Review*, 23/1: 23–31.

van der Borgh, M., Cloodt, M., and Romme, A. G. L. (2012) 'Value Creation by Knowledge-based Ecosystems: Evidence from a Field Study', *R&D Management*, 42/2: 150–69.

Wanzenböck, I., Scherngell, T., and Fischer, M. M. (2013) 'How do Firm Characteristics Affect Behavioural Additionalities of Public R&D Subsidies? Evidence for the Austrian Transport Sector', *Technovation*, 33/2: 66–77.

Wareham, J., Fox, P. B., and Cano Giner, J. L. (2014) 'Technology Ecosystem Governance', *Organization Science*, 25/4: 1195–215.

West, J. and Wood, D. (2013) 'Evolving an Open Ecosystem: The Rise and Fall of the Symbian Platform'. In: R. Adner, J. E. Oxley, B. S. Silverman (eds) *Collaboration and Competition in Business Ecosystems*, pp. 27–67. UK: Emerald Group Publishing Limited.

——, Salter, A., Vanhaverbeke, W., and Chesbrough, H. (2014) 'Open Innovation: The Next Decade', *Research Policy*, 43/5: 805–11.

Westphal, J. and Zajac, E. (1997) 'Defections from the Inner Circle: Social Exchange, Reciprocity, and the Diffusion of Board Independence in US Corporations', *Administrative Science Quarterly*, 12/1: 161–83.

Zahra, S. A. and Nambisan, S. (2012) 'Entrepreneurship and Strategic Thinking in Business Ecosystems', *Business Horizons*, 55/3: 219–29.

—— and Pearce, J. A. (1989) 'Boards of Directors and Corporate Financial Performance: A Review and Integrative Model', *Journal of Management*, 15/2: 291–334.

Zajac, E. (1988) 'Interlocking Directorates as an Interorganizational Strategy: a Test of Critical Assumptions', *Academy of Management Journal*, 21/2: 428–38.

Appendix Table A1. Overview of the results of robustness checks 2, 3 and 4 (Section 4.2)

Robustness check 2: separately introduce the items for behavioral additionality as mediators	
	Unstandardized coefficient (Model 3) and (standard errors)
Item on firm networking	0.3680*** (0.058)
Item on innovation capabilities	0.4907*** (0.046)
Item on speed of progress	0.5310*** (0.041)
Item on skills	0.3812*** (0.040)
Robustness check 3: introduce firm independency[a] as a control variable	
	Unstandardized coefficient (Model 1) and (standard errors)
Firm independency[a] dummy	0.0635** (0.190)
Robustness check 4: introduce ecosystem stage as a moderator in Model 4	
	Unstandardized coefficient (Model 4) and (standard errors)
Moderator = organizational interdependence * starting ecosystem stage	0.2064^{+} (0.190)
Moderator = organizational interdependence * growing ecosystem stage	0.1482^{+} (0.086)
Descriptives (mean (S.D.)) of variables used in the robustness checks	
Item on firm networking	5.965 (1.331)
Item on innovation capabilities	5.331 (1.542)
Item on speed of progress	5.482 (1.589)
Item on skills	4.910 (1.772)
Firm independency[a] dummy	0.545 (0.499)
Starting ecosystem stage	0.159 (0.367)
Growing ecosystem stage	0.380 (0.486)

[a]Independent firms are firms of which less than 50% of the shares are held by another firm.
Significance *level:* $^{+}$P<0.10, *P<0.05, **P<0.01, ***P<0.001.