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Collaboration between competitors' NPD teams: in search of effective modes of management control

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Successful collaboration between new product development (NPD) teams maintained by competitors (so-called horizontal NPD collaboration) requires the use of formal modes of management control that simultaneously coordinate the teams' interdependent development activities and encourage their cooperative behavior. Nevertheless, prior theoretical and empirical research suggests that formal control modes required to improve coordination may also drive uncooperative, opportunistic behavior. To help managers in horizontal NPD collaborations select appropriate control modes, this study draws on organizational theory of management control and develops a conceptual framework that specifies the impact of one partner's use of input, process, and output controls on the other partner's perception of coordination effectiveness and cooperative behavior. The results of a scenario-based experiment with 110 expert practitioners show that managers perceive the competitor's use of input control as harmful and process control as helpful for achieving coordination effectiveness. Moreover, managers respond positively to the competitor's use of input control and negatively to the competitor's use of output control when it comes to cooperative behavior. Together, the results indicate that no single mode of formal management control simultaneously enhances both coordination and cooperative behavior in horizontal NPD collaborations.

1. Introduction

Shrinking product life cycles, converging technologies, and ever-increasing R&D costs push competitors to engage in collaborative new product development (NPD) projects (Gnyawali and Park, 2011), also known as development or R&D alliances, in which they share and pool their resources to develop a new product (Oke et al., 2008). For example, NPD teams from the competitors Toyota and PSA group (Citroen-Peugeot) collaborated to develop the IQ/Peugeot 109; development teams from IBM, Sony, and Toshiba, which are strongly competing in the IT industry, joined forces to devise a high-performance microprocessor (Luo et al., 2007).

Collaborations between competing NPD teams, also called horizontal NPD collaborations, create significant benefits, such as enhanced learning, reduced costs (Luo et al., 2007), and increased product innovation output (both incremental and radical) (Belderbos et al., 2004; Ritala, 2012). Moreover, horizontal NPD collaborations facilitate risk sharing, resource allocation, external knowledge acquisition, and new market and technology access (Oke and Idiagbon-Oke, 2010). However, resources exchanged in the course of NPD collaborations between competitors could well be used for competitive instead of cooperative purposes (Álvarez Gil and González de la Fé, 1999; Ritala and Hurmelinna-Laukkanen, 2012). Horizontal NPD collaborations thus entail a complex strategy of 'sleeping with the enemy' (Sivadas and Dwyer, 2000; Peng et al., 2012), which requires teams to engage in *cooperative behavior* and act in the interest of the collaboration as a whole rather than opportunistically pursue their self-interests (Bengtsson and Kock, 1999; Zeng and Chen, 2003; Gnyawali and Park, 2011).

Besides cooperative behavior, the effective *coordination* of mutually dependent activities across competitors' NPD teams also is a challenging endeavor. During the product development process, the competitors' NPD teams share and pool resources, decompose collaborative activities, and specify the precise division of labor (Gulati and Singh, 1998). The resulting, highly interdependent NPD activities must be effectively coordinated across organizational and team boundaries (Dekker, 2004).

Successful horizontal NPD collaboration thus requires the management of both coordination effectiveness and cooperative behavior, yet, according to Peng et al.'s (2012) review and Gnyawali and Park's (2011) study of competitor collaborations, we know little about how such collaborations should be managed. This study therefore seeks to identify modes of formal management control that are expected to: (1) facilitate *effective coordination* by achieving unity of effort, avoiding activity overlap or duplication, and ensuring synchronization of collaborative activities, and; (2) stimulate *cooperative behavior* across teams by ensuring desired behaviors by the NPD teams involved in the collaboration, such as voluntary and proactive information sharing (Earley and Gibson, 2002; Gerwin, 2004; Griffith et al., 2006).

In identifying these formal modes of control, we explicitly acknowledge that particular modes of control used to stimulate coordination could simultaneously impede cooperative behavior. As a result of particular formal control modes applied by one partner in horizontal collaborations, the other partner might experience a diminished sense of autonomy (e.g. Heide et al., 2007; John, 1984; Provan and Skinner, 1989) or perceive a lack of support for the collaborative project (e.g. Anderson and Oliver, 1987; Atuahene-Gima and Li, 2002; Aulakh et al., 1996). These effects likely reduce the willingness to behave cooperatively. If this line of reasoning holds, the use of formal control modes to encourage coordination may have an unwanted side effect on cooperative behavior between competitors' NPD teams, harming the chances of collaborative success.

In this study, we therefore simultaneously examine the impact of formal control modes on managerial perceptions of both coordination effectiveness and cooperative behavior across competitors' NPD teams. This is important for both theory and practice for several reasons. First, the extant empirical studies on this topic have mostly focused on the role of formal control in achieving cooperative behavior, not effective coordination, let alone both, in collaborations (cf. Velez et al., 2008). The study of Sivadas and Dwyer (2000) is a rare exception, yet, they combine coordination (effectiveness) and cooperative behavior (communication) in one variable named 'cooperative competency'. As a result, their study does not capture the opposite effects that different modes of formal control may have on coordination effectiveness and cooperative behavior. Second, relatively little academic research investigates NPD collaborations between competitors while such collaborations have become the next generation for NPD practices in a world where product innovation is increasingly challenging (Gnyawali and Park, 2011; Peng et al., 2012).

The remainder of this article is organized as follows. The next section reviews relevant literature, provides key definitions, and offers significant theoretical underpinnings. We then present the conceptual framework and hypotheses, followed by a description of the scenario-based experiment we used to test the hypotheses. Afterwards, we detail our data analysis method and results and discuss the implications of our findings. The final section addresses this study's contributions, limitations, and directions for further research.

2. Background literature and definitions

Horizontal NPD collaborations refers to collaborative NPD projects between competitors (Gnyawali and Park, 2011), in which the competitors' teams share and pool their rather similar resources to jointly develop a new product (Oke et al., 2008). The competitors' teams can be colocated or distributed during the collaborative NPD project. Because colocated teams with one assigned NPD team manager are generally considered to be more successful (e.g. Bstieler and Hemmert, 2010; Hoegl and Wagner, 2005), this study focuses on colocated teams.

Of fundamental importance to the success of horizontal NPD collaborations is the effective coordination of their joint activities (e.g. Dyer and Singh, 1998; Gerwin, 2004; Sivadas and Dwyer, 2000) and their cooperative behavior (e.g. Dyer and Singh, 1998; Gnyawali and Park, 2011; Sivadas and Dwyer, 2000; Zeng and Chen, 2003). *Effective coordination* achieves unity of effort (Gerwin, 2004), avoids activity overlap or duplication, and ensures synchronization of collaborative activities (Earley and Gibson, 2002). Effective coordination leads to project efficiency and the (timely) completion of project objectives (Sivadas and Dwyer, 2000). The need for proper coordination between teams in horizontal NPD collaborations is high, because development activities are highly interdependent (Bstieler and Hemmert, 2010). The accomplishment of one team's activities often depends on the degree to which the other team has accomplished its activities (Dekker, 2004). Competitors' NPD teams thus must be aware of one another's activities to synchronize them.

Cooperative behavior involves desired behaviors by the teams involved in the horizontal NPD collaboration, such as voluntary and proactive information sharing (Griffith et al., 2006). Cooperative behavior represents the opposite of opportunistic behavior, which mainly involves self-interestedly withholding or distorting information (Das and Teng, 1998; Das and Kumar, 2011). Encouraging cooperative behavior between competitors' NPD teams is essential for project success. For example, Luo et al. (2007) report that the teams from Sony, IBM, and Toshiba benefited from proactively sharing relevant information for the development of a high-performance microprocessor, because doing so enabled them to lower development costs. Álvarez Gil and González de la Fé (1999) and Bengtsson and Kock (1999) explain however that collaborations are not always based on friendliness due to common (collaborative) interests but also reflect hostility due to conflicting (competitive) interests. Each NPD team involved may benefit from withholding or distorting information, so that it can outperform the other team in terms of design quality, features, cost, and/or timeliness (Sivadas and Dwyer, 2000).

Management control is a process of (inter) organizational regulation and monitoring that seeks to ensure the fulfillment of collaborative NPD plans and goals (Caglio and Ditillo, 2008). It should encourage effective coordination and cooperative behavior between competitors' NPD teams. There are two types of management control. *Formal control* refers to explicitly codified rules, operating procedures, goals, and regulations specifying desirable patterns of behavior (Das and Teng, 1998). Three formal control mechanisms exist: input, process, and output (Jaworski, 1988). *Input controls* are measurable actions prior to the implementation of development activities; *process controls* involve specifying and monitoring ongoing activities and behaviors, as well as regulating how work gets done during the execution of the development project; and *output controls* set, monitor, and evaluate end-of-project performance goals for each NPD team to attain. In contrast, *informal control* consists of unwritten policies, many of which are artifacts of organizational or team cultures (Langfield-Smith, 1997). It relies on norms and values and goal internalization (Das and Teng, 2001). Despite the importance of informal controls, we focus on formal control modes, which are more feasible for managing temporarily colocated NPD teams involved in horizontal collaborative projects. Informal, self-regulating controls typically cannot simply be managerially imposed across teams that are colocated for a limited time only (Arranz and Arroyabe, 2012).

Formal controls help NPD teams involved in a horizontal collaboration establish, decompose, and communicate activities to coordinate their tasks more effectively (Gulati and Singh, 1998; Vlaar et al., 2007; Velez et al., 2008; Chiang and Hung, 2014). They should also stimulate cooperative behavior between competitors' teams and reduce opportunism through sanctions or incentives (Velez et al., 2008). Yet many studies also show that formal controls do not always stimulate cooperative behavior. By enforcing rules, procedures, or goals, formal control actually may diminish NPD teams' sense of autonomy, potentially causing them to resist or act in ways to improve their own conditions, not those of the collaboration (e.g. Heide et al., 2007; John, 1984; Provan and Skinner, 1989). The use of formal control also could be interpreted as a lack of trust, commitment, or support, resulting in increased tension between competitors' NPD teams, which would discourage their cooperative behavior (e.g. Anderson and Oliver, 1987; Atuahene-Gima and Li, 2002; Aulakh et al., 1996). In other words, the use of formal control might have opposite effects (i.e. positive or negative) on the cooperative behaviors between competitors' NPD teams.

3. Conceptual framework and hypotheses

Our conceptual framework (see Figure 1) draws on theoretical and empirical management control studies to identify effective modes of formal control for managing horizontal NPD collaborations. We particularly focus on how NPD team managers perceive and respond to formal modes of control used by the competitor. Collaboration is most likely to succeed when the managers positively perceive the competitor's use of formal control – differentiated into input, process, and output forms – in terms of both coordination of collective NPD activities and stimulation of cooperative behavior. Yet, NPD team managers might also negatively experience the competitor's use of formal control when it comes to cooperative behavior (e.g. Atuahene-Gima and Li, 2002; Aulakh et al., 1996; Heide et al., 2007; Provan and Skinner, 1989).

3.1. Management control and coordination effectiveness

In horizontal collaborations, NPD team managers are expected to perceive the competitor's use of input control as improving the coordination of interdependent activities. By definition, input control ensures clear communication of the development plan and general expectations to the managers and their teams. Input control helps NPD team managers better understand what their partner will do and what type of help it may need or expects to receive to succeed (Marks et al., 2002). Input control thus acts like a type of product development charter as it provides NPD managers and their teams a common focus during the course of the development project. Additionally, with input control, the managers and their teams socialize and become familiar with each other's expertise which stimulates cross-pollination among team members and joint problem solving (Keller, 2001; Chen et al., 2010), and minimizes the level of divergence in preferences and behaviors (Eisenhardt, 1985). As such, NPD team managers can more efficiently and effectively align and synchronize their interdependent development activities (Cannon-Bowers and Salas, 2001) as a result of which they are more proficiently executed. As with input control plans and expectations are clearly communicated and the level of team preference divergence is minimized, the collaborative NPD project is easier to implement and development tasks better conductible, so NPD team managers are likely to positively experience the competitor's use of input control for coordination effectiveness. Therefore:

H_1: *The competitor's use of input control positively affects NPD team managers' perception of coordination effectiveness within the collaborative project.*

In an NPD team manager's perception, the competitor's use of process control in a horizontal NPD collaboration is expected to facilitate the coordination of the separate teams' development activities. In plain words, process control structures the NPD process and activities (Ouchi, 1979; Poskela and Martinsuo, 2009; Schultz et al., 2013) which makes it easier to perform them proficiently. It helps team managers avoid overlooking critical NPD activities or performing them out of sequence, and integrate the different perspectives, knowledge, and demands of the teams involved (Bonner et al., 2002). Even if unexpected events occur and product specifications must be changed while the project is ongoing, the use of process control encourages information exchanges and ensures coordination between the tasks conducted by the different teams (Rijsdijk and Van den Ende, 2011). With process control, development activities are monitored on a regular basis and deviations from the project plan can, as such, more easily be detected and corrected. For the reason that process control helps NPD team managers structure the NPD process and activities, managers are expected to positively perceive the competitor's use of process control for achieving coordination effectiveness. Thus:

H_2: *The competitor's use of process control positively affects NPD team managers' perception of coordination effectiveness within the collaborative project.*

Finally, NPD team managers in a horizontal NPD collaboration are likely to perceive that with the competitor's use of output control, the coordination of interdependent activities improves. Although output control represents a hands-off approach (e.g. Atuahene-Gima and Li, 2002; Aulakh et al., 1996) so the NPD team managers are left alone to perform their team's activities in such a way that preset output

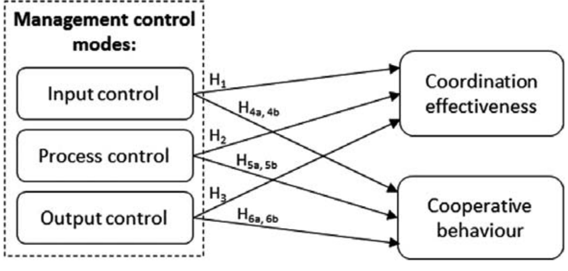

Figure 1. Conceptual framework.

requirements are achieved (Heide et al., 2007), output control makes it easier to identify, and proficiently perform these activities (Das and Teng, 1998). There is ample empirical proof that goal clarity contributes to NPD team focus and motivation (Sivasubramaniam et al., 2012), especially when the goals, just like in collaborative NPD projects, are challenging (Locke and Latham, 2002). This increased focus and motivation allows the development team to better comprehend the collaborative project goals and avoids misunderstanding and miscommunication between the teams and their members about what to jointly realize (Atuahene-Gima, 2003). Ambiguous output requirements may, in contrast, result in team conflicts, hampering the project's successful execution and completion (Chen et al., 2010). Moreover, as the use of output control prevents NPD team managers to speculate about what is to be developed, it evades unnecessary changes of direction during project execution (Swink, 2003; Rijsdijk and Van den Ende, 2011). The autonomy that managers receive to choose and perform their team's interdependent activities also enables them to adapt more readily to unexpected changes in requirements and workload (Snell and Youndt, 1995). The clear goals, as well as the freedom in choosing and performing development activities that go with output control, help team managers in horizontal NPD collaborations to better execute the collaborative project, upon which NPD team managers should positively experience the competitor's use of output control for coordination effectiveness. Therefore:

H_3: *The competitor's use of output control positively affects NPD team managers' perception of coordination effectiveness within the collaborative project.*

3.2. Formal control and cooperative behavior

The literature provides conflicting indications about how NPD team managers perceive the competitor's use of formal control modes for cooperative behavior. This is why arguments for both positive and negative effects of the different types of formal control on cooperative behavior are given (for a rationale of this approach see Armstrong et al., 2001; Srinivasan et al., 2004).

Snell and Youndt (1995) and Eisenhardt (1985) indicate that NPD team managers in a horizontal NPD collaboration are expected to perceive the competitor's use of *input control* as positively influencing cooperative behavior. The reason is that input control 'helps to socialize the team members to ensure they have requisite abilities as well as understand and internalize the values and goals of the horizontal NPD collaboration' (Snell and Youndt, 1995, p. 713). This understanding and internalization of the collaboration's values and goals advances mutual support among managers and their teams to cooperate and achieve collaborative goals (Eisenhardt, 1985). Mahama (2006) concurs by arguing that input control generates interpersonal relationships and feelings of attachment between the partners' managers and their teams, which suppresses the desire to act in the disadvantage of the other team. Moreover, the use input control stimulates the other team to also take possession of the joint NPD project. Besides, the competitor's use of input control shows that it is willing to share important development knowledge and expertise. This way, the competitor expresses a cooperative attitude, which encourages the partner's NPD manager and team to also adopt a cooperative mindset and attitude. The use of input control also constitutes a hands-off approach with no room for intervention that undermines autonomy, thereby reducing the probability of defending own interests at the expense of collaborative ones (Heide et al., 2007). Instead, the given autonomy will intrinsically motivate NPD team managers to invest more time and energy to successfully complete assigned development activities, and thus to cooperate more actively with the partner's team. Considering the focus of input control on relational aspects and the team autonomy that input control allows for, NPD team managers are expected to positively experience the competitor's use of input control as regards cooperative behavior. Thus:

H_{4a}: *The competitor's use of input control positively affects NPD team managers' perception of cooperative behavior within the collaborative project.*

Gnyawali and Park (2011) suggest, on the other hand, that in horizontal NPD collaborations, team managers probably perceive the competitor's use of input control as impeding cooperative behavior. With input control, important (tacit) skills and resources are being shared among the developers in the competitors' teams, which can be used for competitive rather than cooperative ends (Gnyawali and Park, 2011). Considering that, together with the hands-off approach of input control, NPD team managers might be reluctant to actively cooperate for fear of the competitor's team misusing the valuable (tacit) knowledge for competitive purposes. Furthermore, the training aspect of input control shows little confidence in the level of knowledge and skills of the partner's manager and team, creating an atmosphere of distrust and, as such, discouraging cooperative behavior. Finally, the hands-off approach of input control may, in horizontal NPD collaborations, be perceived as inappropriate or even deceptive, as it provides an opportunity to pinch and misuse important know-how. As such, NPD team managers are likely to negatively respond to the competitor's use of input control. And so:

H_{4b}: *The competitor's use of input control negatively affects NPD team managers' perception of cooperative behavior within the collaborative project.*

Aulakh et al. (1996) and Atuahene-Gima and Li (2002) give arguments for team managers in an NPD collaboration with a competitor to positively experience the competitor's use of *process control* for cooperative behavior. Process control improves coordination among interdependent activities of the teams involved in the NPD collaboration as it reduces task ambiguity and uncertainty (Li and Atuahene-Gima, 1999; Chen et al., 2010). Moreover, with process control, managers and their teams are likely to increasingly identify with and feel committed to the horizontal NPD collaboration, thus willing to cooperate more as part of one large team (Anderson and Oliver, 1987). Through process control, the partners communicate and interact frequently and, as such, progressively develop interpersonal relationships and mutual feelings of attachment (Mahama, 2006). According to Bstieler and Hemmert (2010), this feeling of commitment and mutual respect will stimulate cooperative behavior during the development project through increased cohesiveness. Moreover, Beal et al. (2003) found that these strongly bonded NPD teams are more effective in the execution of their development tasks. Process control also maximizes the ability of teams to detect each other's opportunism during the joint NPD project (Stump and Heide, 1996; Wathne and Heide, 2000; Das and Teng, 2001; Das and Kumar, 2011). This increased chance of exposure stimulates cooperative behavior and discourages opportunistic behavior of teams. As with process control, commitment and support is demonstrated through persistent communication, and as opportunistic behavior is easily identified and therefore discouraged, NPD team managers are expected to positively react to the competitor's use of process control regarding cooperative behaviour. Therefore:

H_{5a}: *The competitor's use of process control positively affects NPD team managers' perception of cooperative behavior within the collaborative project.*

Heide et al. (2007) imply the opposite, that is, in an NPD team manager's perception, the use of process control by the competitor has a negative impact on cooperative behavior. It may cause negative attitudes between the NPD teams (Poskela and Martinsuo, 2009) and demotivation (Kreutzer et al., 2014) for several reasons. Because the use of process control enforces strict rules stipulating which NPD activities must be performed and how they should be performed (Chiang and Hung, 2014), process control is expected to be perceived as being intrusive and distrustful, causing defensive opportunistic behaviors (Heide et al., 2007). NPD team managers and members will feel controlled and unheard. The competitor also seems to have difficulties relying on the knowledge and skills of the partner's manager and team, showing distrust and, as such, discouraging cooperative behavior. Moreover, process control constitutes a hands-on approach with little or no room for autonomy, which could lead to frustrated and demotivated team members being reluctant to actively cooperate. This is in line with Provan and Skinner's (1989) rationale that process control limits autonomy in the execution of NPD activities, which team managers and their teams will try to defend by engaging in opportunistic instead of cooperative behavior during the joint development project. In view of the rather forceful and intrusive nature of process control, NPD team managers probably perceive the competitor's use of process control negatively as to cooperative behavior. Thus:

H_{5b}: *The competitor's use of process control negatively affects NPD team managers' perception of cooperative behavior within the collaborative project.*

According to Provan and Skinner (1989) and Heide et al. (2007), NPD team managers involved in a horizontal collaboration should positively perceive the competitor's use of *output control* regarding cooperative behavior. Output control, just like input control, constitutes a hands-off approach, which supports autonomy. As such, managers and their teams will, at least, not be inclined to engage in opportunistic, uncooperative behavior during the joint NPD project (Provan and Skinner, 1989; Heide et al., 2007). On the contrary, because of this noninterventionist approach, output control demonstrates a sense of mutual trust and confidence in achieving positive NPD outcomes, which stimulates managers and team members to actively engage in cooperative behavior. Besides, output control places social pressure on the managers and their teams to achieve such positive outcomes because they do not want to violate the other team's trust by letting them down, thereby increasing the likelihood of compliance and cooperative behavior to the project plan (Wathne and Heide, 2000). Also in line with goal-setting theory, output control is expected to increase cooperative behavior through fostering the motivation, engagement, and commitment of the NPD team manager and members (Kreutzer et al., 2014). Considering the trustful nature of output control and the social pressure to achieve results, NPD team managers are expected to favorably perceive the competitor's use of output control when it comes to cooperative behavior. Accordingly:

H_{6a}: *The competitor's use of output control positively affects NPD team managers' perception of cooperative behavior within the collaborative project.*

Alternatively, Aulakh et al. (1996) and Atuahene-Gima and Li (2002) give arguments for team managers to negatively experience the competitor's use of output control as to cooperative behavior. The authors argue that output control likely raises the tension between the partners in the horizontal NPD collaboration because the strong focus merely on achieving outcomes might engender the perception of not being supported by the other team (Anderson and Oliver, 1987). This feeling of being left to one's own devices might discourage NPD managers and their teams to cooperate with the competitor's team during the NPD project. Also, with output control, NPD team managers and members will strive for goal realization, which might go at the expense of cooperative behavior (Wright et al., 1993). Moreover, output control does not, in comparison to input and process control, drive managers and their teams to develop interpersonal relationships and feelings of attachment, or stimulate teams to frequently communicate and interact with each other. This results in a reduced willingness to take project ownership and less commitment to the collaborative project's goals. Output control may also be seen as a form of bribery (Poskela and Martinsuo, 2009), which will go at the expense of a cooperative attitude. In consideration of this unsupportive and passive nature of output control, NPD team managers might negatively experience the competitor's use of output control for cooperative behavior. Therefore:

H_{6b}: *The competitor's use of output control negatively affects NPD team managers' perception of cooperative behavior within the collaborative project.*

4. Methodology

Experimental designs have served to investigate management practices in NPD (Schmidt et al., 2001; Faure, 2009; Harvey and Victoravich, 2009; Magnusson, 2009; Fuchs and Schreier, 2011), as well as interorganizational relationship contexts (Patzelt and Shepherd, 2008; Tangpong et al., 2010; Patzelt et al., 2011). An experimental approach avoids practitioners' reluctance to provide candid, unambiguous, and complete information about their actual practices and the outcomes of their own NPD collaborations with competitors. Instead, we developed scenarios representing realistic situations to elicit people's perspectives on the effects of management control on collaborations between competitors' NPD teams. These scenarios allow respondents to offer more dispassionate, objective answers than if they reported their own project experiences.

4.1. Instrument development and pretest

The experiment uses a 2 (input control: yes/no) × 2 (process control: yes/no) × 2 (output control: yes/no) between-subject design to test the hypothesized effects. The experiment's situation setting is adapted from a description of an actual collaboration between the NPD teams of Sony and Samsung, offered by Gnyawali and Park (2011). The eight scenarios representing different combinations of levels of management control policies were developed specifically for this study. Although fictitious, the scenarios are realistic descriptions of collaborative management control practices (e.g. Jaworski, 1988).

The experiment's situation setting, scenarios, and measure response questions were pretested to assure that they clearly and unambiguously expressed the substantive content of interest and had face validity as representations of conceivable management control policies in a collaborative product development setting. The scenarios were provided to eight experienced R&D engineers at a high-tech company in the Netherlands who critically assessed the scenarios and provided feedback on scenario and question clarity, interpretation, specificity, and any potential ambiguities. Minor revisions to the scenarios were made in response to their feedback. The revised instrument was then closely reviewed by faculty and doctoral students having experience in conducting behavioral experiments, NPD project management, and interorganizational relationships. Appendix A contains the final experiment wording and the eight scenarios.

4.2. Experiment administration and participants

We sent invitations to members of the Product Development Management Association (PDMA) in the

Netherlands and Belgium, R&D engineers from Dutch high-tech companies, and members of a Horizontal Collaboration Discussion Forum (HCDF). The PDMA members are appropriate respondents, because they are experienced, highly involved product development professionals. The R&D engineers also indicated their active involvement in cross-firm development projects. Finally, HCDF members participate in a discussion group that primarily represents supply chain professionals involved or interested in managing competitor collaborations.

Participation was voluntary and the online instrument was in English. We relied on the Qualtrics service to communicate the invitations, experiment, and follow-up notes. All participants received the same background information about the collaboration setting. After reading this information, they were randomly assigned to one of eight scenarios. In all cases, they assumed the role of an NPD manager, in charge of the development team of one of the two collaborating competitor firms. The scenarios differed in whether input, process, or output controls are applied. Having read the scenario description, the participants indicated their perceptions of input, process, and output control, and then completed a short questionnaire containing multi-item scales to measure their response to different levels of input, process, and output control in terms of coordination effectiveness and cooperative behavior.

The first round of invitations was sent during July–August 2012, with a reminder sent three weeks later. The invitation letter described the importance of the study, stipulated respondent qualification requirements, and offered, as an incentive for participation, a managerial report of the study findings. In total, 110 persons completed the experiment, for an effective response rate of 17.1%, which compares favorably with those achieved in previous web-based studies (Klassen and Jacobs, 2001). Specifically, 41 PDMA members (20.1% subset response rate), 52 R&D engineers (41.3% subset response rate), and 17 HCDF members (5.4% subset response rate) completed the instrument. In terms of their demographics, their average age was 41.3 years, and they had an average of 10.3 years of experience in their current function. Eighty percent of the respondents held graduate degrees (9% MBA, 55% other masters' degrees, 16% doctorates), 19% had bachelor's degrees, and 1% had a high school diploma. Men constituted 92% of the sample.

We tested for any significant differences across subsamples, because of the potential for heterogeneity in the different subsample groups (PDMA members, R&D engineers, and horizontal collaboration professionals). One-way analyses of variance (ANOVAs) for coordination effectiveness and cooperative behavior indicated no significant respondent differences, so we pooled the subsamples for our subsequent data analysis. We also tested for significant differences across the participants' industries and did not find any. In addition, to test for nonresponse bias, we compared all variables provided by early and late respondents, based on a median split of when a respondent participated. In ANOVAs performed across all variables, we found no significant differences and have no reason to believe that nonresponse bias was an issue for this study.

4.3. Dependent variables: coordination effectiveness and cooperative behaviour

Within each control scenario, participants gave their perceptions of coordination effectiveness and cooperative behavior between NPD teams on seven-point, multi-item, Likert-type scales. For coordination effectiveness, we used three items adopted from Earley and Gibson (2002), such that participants indicated the extent to which they agreed that joint development activities were effectively coordinated, overlap, and duplication in development activities was avoided, and problems with synchronizing activities were avoided. We used six items adopted from Griffith et al. (2006) to measure cooperative behavior, that is, the extent to which they would adapt activities to new or changed development requirements; provide any information that might help the competitor's team; frequently and informally provide information to the competitor's team; provide the competitor's team with proprietary information if helpful; keep the competitor's team informed about events or changes in activities; and help the competitor's team when it incurred problems. Table 1 presents the scale operationalizations.

4.4. Unidimensionality, reliability, and validity

An exploratory factor analysis confirmed the unidimensionality of the measures. Consistent with Steenkamp and Van Trijp (1991), we employed eigenvalues ≥ 1.0 and factor loadings $\geq .30$ as threshold values. Confirmatory factor analysis allowed us to examine the reliability and validity of the main constructs. The results in Table 1 showed that the parsimonious fit measure (χ^2/df) fell well within the recommended threshold of 5.0 (Marsh and Hocevar, 1985), and the relative fit indices (normed fit index, non-normed fit index, con-

Table 1. Scale items, standardized loadings (SL), *t*-values (*t*), and psychometric properties

In view of the background information about the collaboration between Sony and Samsung and the previously described development project of the ninth generation LCD panels in which you act as Sony's product development manager, to what extent do you agree with the following statements:

Coordination effectiveness (Earley and Gibson, 2002) AVE = .40, CR = .64, α = .62		SL	*t*
1.	Samsung effectively coordinates the joint development activities.	0.43	4.03
2.	Samsung avoids that development activities overlap or are being duplicated, thus, that work is done twice.	0.47	4.35
3.	Samsung avoids that you and your team have problems in synchronizing development activities to the development activities performed by Samsung's team.	0.88	7.15
Cooperative Behaviour (Griffith et al., 2006) AVE = .48, CR = .84, α = .83			
You and your team are willing to . . .			
1.	adapt your activities to changed development requirements that come from events or changes in Samsung's team's activities.	0.69	7.78
2.	provide any information that might help Samsung's team in executing its development activities.	0.66	7.47
3.	frequently and informally provide information to Samsung's team, thus not only during the weekly meetings.	0.65	7.32
4.	provide Samsung's team with proprietary information of Sony if it can help Samsung's team in executing its development activities.	0.39	4.02
5.	keep Samsung's team informed about events or changes in your activities that may affect Samsung's team's activities.	0.78	9.26
6.	help Samsung's team when the team incurs problems with particular development activities.	0.88	11.13

Fit indices: χ^2/df = 1.48, normed fit index = .93, non-normed fit index = .97, confirmatory fit index = .97.AVE, average variance extracted; CR, composite reliability.

Table 2. Descriptive statistics, reliability statistics, and correlations

	# Items	*Mean*	*S.D.*	1	2	3	4	5
Dependent variables (measured)								
1. Coordination effectiveness	3	4.67	1.43	*0.62*				
2. Cooperative behavior	3	4.87	1.11	0.24***	*0.83*			
Manipulated variables								
3. Input control	n.a.	n.a.	n.a.	–0.25***	0.16*	n.a.		
4. Process control	n.a.	n.a.	n.a.	0.19**	–0.04	–0.15	n.a.	
5. Output control	n.a.	n.a.	n.a.	–0.16*	–0.39***	0.02	0.04	n.a.

Reliability coefficients are shown in *italics* on the diagonal. *$p \leq .10$. **$p \leq .05$. ***$p \leq .01$. n.a., not available; *S.D.,* standard deviation.

firmatory fit index) all exceeded the threshold value of .90. Composite reliabilities (CR) also exceeded the .70 threshold for acceptable reliability (Bagozzi and Yi, 1988). The average variance extracted (AVE) values approached the .50 threshold. In support of convergent validity, all items loaded significantly on their respective construct factor (Bagozzi et al., 1991). The AVE for any pair of variable measures was greater than the square of the correlation estimates between those two variable measures, in support of discriminant validity (Fornell and Larcker, 1981). Collectively, these tests indicate acceptable psychometric properties for the two measured variables. We obtained the respective variable measures by simple averages of the scale items. Table 2 contains the descriptive and correlational statistics for both measured variables.

4.5. Manipulation tests

We assessed respondents' perceptions of the formal control levels to check our manipulations. For input, process, and output controls, respectively, they reported on a seven-point Likert-type scale the extent

Table 3. Means and standard deviations (SDs) for coordination effectiveness and cooperative behavior

Scenario	Input control	Process control	Output control	Participants	Measures	Coordination effectiveness	Cooperative behavior
1	yes	no	no	17	Average	4.45	5
					(SD)	(0.99)	(0.85)
2	no	yes	no	17	Average	5.59	5.17
					(SD)	(0.78)	(0.78)
3	no	no	yes	12	Average	4.81	3.6
					(SD)	(1.00)	(1.38)
4	yes	yes	no	10	Average	4.9	4.77
					(SD)	(0.85)	(0.93)
5	yes	no	yes	14	Average	4.31	4.69
					(SD)	(1.39)	(0.86)
6	no	yes	yes	15	Average	4.82	3.66
					(SD)	(1.02)	(1.07)
7	yes	yes	yes	12	Average	4.83	4.19
					(SD)	(1.36)	(1.32)
8	no	no	no	13	Average	5.18	4.64
					(SD)	(1.04)	(0.98)

to which they agreed that the competitor's NPD team (1) invested in proper training programs (Jaworski, 1988; Cardinal, 2001); (2) provided supervision and guidance during the joint development project (Ouchi, 1979; Cardinal et al., 2004), and (3) dictated, at the beginning of the project, development requirements that would be evaluated at the end of the project (Jaworski, 1988; Dekker, 2004).

Participants in the input control condition scored significantly ($p \leq .001$) higher on the input control scale (M = 5.49, SD = 1.31) than did those in the condition without input controls (M = 3.98, SD = 1.88). Similarly, participants in the process control condition scored significantly ($p \leq .01$) higher on the process control scale (M = 5.59, SD = 1.24) than those in the condition without process control (M = 4.84, SD = 1.78). Finally, participants in the output control condition scored significantly ($p \leq .001$) higher on the output control scale (M = 5.92, SD = 1.28) than those in the condition without output control (M = 3.70, SD = 1.89). Together, these results affirmed the effectiveness of the manipulations.

5. Results

To test how managers perceive input, process, and output controls in terms of coordination effectiveness and cooperative behavior, we undertook a $2 \times 2 \times 2$ multivariate analysis of covariance with the controls as the independent variables and coordination effectiveness and cooperative behavior as the dependent variables. In Table 3 we report the scenario means and standard deviations for coordination effectiveness and cooperative behavior.

The results in Table 4 indicate no support for H_1, because input control ($F = 7.19$, $p \leq .01$) negatively affects coordination effectiveness. According to the means, coordination effectiveness is greater in conditions without input control (M = 5.13, SD = .99) than in those with input control (M = 4.58, SD = 1.17). For cooperative behavior, input control exerts a positive impact ($F = 3.93$, $p \leq .05$) in support of H_{4a} and thus not supporting H_{4b}. Cooperative behavior is higher in the input control conditions (M = 4.69, SD = 1.01) compared with the no input control conditions (M = 4.32, SD = 1.23). Furthermore, the results support H_2 as process control ($F = 4.34$, $p \leq .05$) enhances coordination effectiveness. The mean values showed that coordination effectiveness is higher in the process control conditions (M = 5.08, SD = 1.04) than in those without process control (M = 4.66, SD = 1.14). Process control ($F = 0.04$, $p > .10$) has no significant effect on cooperative behavior though, so we cannot confirm H_{5a} or H_{5b}. Finally, output control ($F = .05$, $p > .10$) has no significant effect on coordination effectiveness, thus find no support for H_3. Yet output control significantly and negatively affects cooperative behavior ($F = 6.49$, $p \leq .05$), supporting H_{6b} and thus not supporting H_{6a}. Cooperative behavior is

Table 4. 2 × 2 × 2 MANCOVA of coordination effectiveness and cooperative behavior

	Dependent variable		Mean square	F	η^2
Input control	Coordination effectiveness	H1	7.19	7.24***	0.07
	Cooperative behavior	H4a–H4b	3.04	3.93**	0.04
Process control	Coordination effectiveness	H2	4.31	4.34**	0.04
	Cooperative behavior	H5a–H5b	0.03	0.04	0.00
Output control	Coordination effectiveness	H3	0.05	0.05	0.00
	Cooperative behavior	H6a–H6b	5.02	6.49**	0.06
Input control × Process control	Coordination effectiveness		0.92	0.92	0.01
	Cooperative behavior		1.83	2.37	0.02
Input control × Output control	Coordination effectiveness		0.25	0.25	0.00
	Cooperative behavior		1.43	1.85	0.02
Process control × Output control	Coordination effectiveness		0.07	0.07	0.00
	Cooperative behavior		0.56	0.72	0.01
Input control × Process control ×	Coordination effectiveness		0.42	0.42	0.00
Output control	Cooperative behavior		0.10	0.14	0.00

*$p \leq .10$. **$p \leq .05$. ***$p \leq .01$.MANCOVA, multivariate of analysis of covariance.

greater in the conditions without output control (M = 4.93, SD = 0.88) than those with it (M = 4.04, SD = 1.21).

6. Discussion and implications

For collaborations between competitors' NPD teams to succeed, formal modes of management control should simultaneously fulfill two purposes: stimulate teams to cooperate and coordinate interdependent team activities (e.g. Caglio and Ditillo, 2008; Dekker, 2004; Velez et al., 2008). Several studies have indicated that formal management controls used to stimulate coordination also discourage cooperative behavior, because they confine teams' autonomy (e.g. Heide et al., 2007; John, 1984; Provan and Skinner, 1989) and signal a lack of commitment to the collaborative project (e.g. Anderson and Oliver, 1987; Atuahene-Gima and Li, 2002; Aulakh et al., 1996). To identify effective modes of formal management control, this study therefore examined how NPD practitioners perceive how specific formal controls affect coordination effectiveness of joint NPD activities and cooperative behavior. We provide insights into effective interorganizational modes of formal control for managing NPD collaborations with competitors, as we summarize in Table 5.

First, team managers perceive that the competitor's use of input control hinders coordination but enhances cooperative behavior in horizontal NPD collaborations. The negative effect of input control on the coordination of interdependent activities is rather unexpected. As a post hoc explanation, we posit that, even though with input control NPD managers and their teams are well informed about plans and skills before the project starts, there is little to no communication and alignment during the project itself. From the NPD team managers' perspective, input control may, as such, result in rather ineffective coordination of interdependent activities (Bstieler and Hemmert, 2010). Additional research is needed to substantiate this explanation though. In addition to its negative effect on coordination, NPD team managers perceive that input control enhances cooperative behavior, likely because it grants members of the competitive teams an opportunity to socialize and familiarize themselves with one another, such that they better understand and internalize the collaboration's values and goals and feel encouraged to cooperate. The use of input control in collaborative NPD projects thus does not create a risk of inducing opportunistic behavior, but rather is consistently beneficial in terms of the cooperative behavior of the teams.

Table 5. Summary of results

Management control mode	Effect on coordination effectiveness	Effect on cooperative behavior
Input control	Negative	Positive
Process control	Positive	Nonsignificant
Output control	Nonsignificant	Negative

Second, NPD team managers recognize that process control has a positive effect on coordination and no impact on cooperative behavior. Through supervision and guidance, complications and inefficiencies that arise during project execution can be detected and solved and major errors prevented, which benefits the coordination of joint activities. Our finding that process control does not affect team members' cooperative behavior is surprising in view of prior reports of positive (e.g. Atuahene-Gima and Li, 2002; Aulakh et al., 1996) and negative (e.g. Heide et al., 2007; Provan and Skinner, 1989) effects. Perhaps, these positive and negative effects cancel each other out statistically or maybe neither positive nor negative effects actually accrue. In the latter case, the use of process control would not lead to increased identification with, or commitment to the collaboration. Instead, members avoid uncooperative behavior only because process control maximizes the possibility of others detecting their opportunism. Both explanations warrant additional research.

Third, with regard to output control, our findings reveal no perceived effect on coordination and a negative effect on cooperative behavior. From team managers' perspective, output control is not perceived as appropriate for coordinating interdependent activities between competitors' NPD teams. This interesting finding is particularly notable in view of prior indications that setting performance goals (output control) is essential for collaborative projects as it provides direction to competitive NPD teams (Bonner et al., 2002). Perhaps the radicalness of the project in our experiment prompted this unexpected finding as it is rather difficult to specify the outcomes of uncertain projects. This explanation requires further substantiation though. Furthermore, our results show that NPD team managers perceive output control as negatively influencing cooperative behavior, consistent with Atuahene-Gima and Li's (2002) and Aulakh et al.'s (1996) suggestions that heavy reliance on quantitative measures of performance raise tension between NPD teams and decrease cooperative behavior. The drawbacks of using output control thus outweigh its often postulated benefits (Provan and Skinner, 1989; Heide et al., 2007) in the context of collaborative NPD projects.

Overall, we find that no single mode of formal control simultaneously improves the coordination of the joint NPD activities and encourages cooperative behavior between competitors' NPD teams. The use of input control results in opposite effects on coordination and cooperative behavior; process control improves coordination but has no effect on the cooperative behavior of NPD teams; and output control has no effect on the coordination of interdependent activities and negatively affects cooperative behavior between teams. For NPD collaborations with competitors to be successful, NPD team managers must thus very cautiously select the right types of formal management controls. Striking the right balance might prove to be very difficult though. For that purpose, NPD team managers are advised to use the tentative decision matrix as represented in Figure 2.

		Cooperative behaviour	
		Low	High
Coordination effectiveness	Low	*Process and input control*	*Process control*
	High		

Figure 2. Tentative decision matrix.

In case team managers in a horizontal NPD collaboration feel that cooperative behavior is satisfactory yet want to improve the coordination of interdependent activities, they are advised to use process control (and process control only). Process control has no impact on the level of cooperative behavior and will only positively impact coordination effectiveness. When cooperative behavior is perceived as being inadequate, however, team managers should use process control together with input control. Input control will stimulate cooperative behavior. Yet, it will result in coordination ineffectiveness. For that reason, process control is needed to counteract that negative effect of input control on coordination. Combining input and process control should be done very carefully though so the positive effect of process control on coordination does outweigh the negative effect of input control. Striking the right balance might prove to be very difficult though.

7. Limitations and further research directions

As with all research, this study has several limitations that should be taken into account when interpreting and evaluating its results. First, we chose an experiment to examine the influence of the three modes of formal control on perceived coordination effectiveness and cooperative behavior between competitors' NPD teams, which inherently results in a stylized research setting. Additional testing of our results using different methodologies would be helpful. Second, we decided to manipulate the three modes of formal control using the perspective of one of the partners (i.e. Samsung) and measure the perceived effects on coordination effectiveness and cooperative behavior using the perspective of the other (i.e. Sony). Further research should however find a way to impose formal controls on both partners and also measure the behavioral effects of control on both sides of the collaboration. Third, this study focuses on control coming from the competitor; yet, controlling actions can also come from another source, for example a neutral steering committee. Perceptions of coordination effectiveness and cooperative behavior are expected to differ with the source of control, which should be confirmed by further investigation. Fourth, we measure perceptions of coordination effectiveness and cooperative behavior on the individual level, i.e. the NPD team manager, because we believe that the NPD team managers pass on these perceptions to their teams. Future research should investigate whether the same results hold on the team level and also investigate how perceptions resonate in team behaviors. Fifth, we focused on two separated NPD teams participating in a horizontal collaboration because this is common practice. Yet, competitors' NPD teams may also be colocated with one assigned NPD team manager in which case our findings might not hold. Further investigation is needed to find out whether our findings are generalizable to the case of a colocated NPD team with one manager. Sixth, the sample is relatively small for testing our hypotheses. Although the sample consists of experienced practitioners only, increasing the credibility of the results, the findings still need additional testing, using larger, independent samples. Seventh, the experimental setup restricted us to simultaneously investigate the effect of the control types on coordination effectiveness and cooperative behavior. Future research might however also investigate a model in which the effect of the control modes on coordination effectiveness is mediated by cooperative behavior. Finally, the CR and AVE for the coordination construct fell just below the preferred threshold values. Because the other psychometric properties for the construct were satisfactory we assumed convergent and discriminant validity, but the limitation remains.

In addition to suggestions to address these limitations, several other lines of research also seem worthwhile. To contribute to the ongoing debate about the nexus between management control and trust, researchers could add trust to our experimental manipulations. Another interesting direction would be to apply the experimental design to NPD collaborations with customers and/or suppliers, to identify effective modes of formal control for downstream and upstream collaborative NPD projects. Researchers also might want to investigate the impact of informal controls on coordination effectiveness and cooperative behavior. Finally, project innovativeness might be considered a trade-off with regard to cooperative behavior and coordination effectiveness warranting further research.

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Appendix A

Experiment Background and Scenarios

Background information

The experiment covers the partnership between two large rivals in the electronics industry: Samsung Electronics and Sony Corporation. For many years, Samsung's key mission was to unseat Sony as the world's top electronics maker, and both Sony and Samsung competed vigorously in many product-markets, such as television, computer, video, audio, and handset, as well as in various geographic markets in the United States, Europe, and Asia. Despite their fierce rivalry, the two firms established an alliance called S-LCD to develop and produce seventh generation liquid crystal display (LCD) panels for flat screen TVs. Both firms initially invested about €750 million, which tripled while moving on to the eighth generation technology. Moreover, Samsung contributed its technological strengths in the LCD technology, while Sony contributed its technological strengths and brand recognition in television. Through S-LCD, Samsung could achieve economies of scale and win the battle for the technological standard and Sony could catch up with the rapidly growing flat screen TV market.

To stimulate collaboration, Sony and Samsung have cross-licensed their patents so that each party is able to practice the inventions covered by the patents included in the agreement. To maintain uniqueness, however, so-called 'Differentiated Technology Patents,' such as Sony's PlayStation architecture and Samsung's home networking technology, are excluded in the cross-licensing agreement. The agreement also does not apply to thin-film transistor LCD and organic light-emitting diode (OLED) display patents. As such, the companies are still competing fiercely in developing new technologies and products inside and outside the flat screen TV market. For example, while Sony was first to introduce an LCD TV with its Bravia model and became industry leader, Samsung countered with its Bordeaux model and overtook Sony. Likewise, Sony launched the first 11-inch OLED TV to which Samsung responded quickly with a 31-inch OLED TV.

Scenarios

Recently, Sony and Samsung have decided to produce 9th generation LCD panels. To that end, both companies have composed one team each that jointly work on the development of the new technology. Sony has put you, as product development manager, in charge of its team. To ease communication and promote collaboration, you and your team are co-located with Samsung's product development manager and team up until the new LCD panels are ready for production.

Input control condition: Before the start of the development, Samsung organizes a training program in which you, your team, and Samsung's team are being prepared for the development of 9th generation LCD panels. Particularly, Samsung shows a layout of the development plan, communicates general expectations, and teaches a range of worthwhile development skills. During the training program, you get the opportunity to socialize and familiarize with each other.

Process control condition: During the project, Samsung provides thorough supervision and guidance. Specifically, Samsung's product development manager monitors whether development activities are being well executed and, if necessary, intervenes to take corrective measures. As such, complications can be detected and solved, and major errors prevented.

Output control condition: At the beginning of the project, Samsung dictates development requirements, which are evaluated by Samsung's product development manager at the end of the project. Concretely, Samsung specifies schedules, deadlines, and budgets that you, your team, and Samsung's team should comply with. Moreover, Samsung prescribes the technical features and design aspects that the LCD panels should meet. At the end, Samsung's product development manager checks whether the project deliverables fulfill the predefined requirements; conformities are awarded whereas departures are penalized.

You and your team will meet with your colleagues from Samsung each week to discuss your ideas, talk about difficulties, and evaluate the project's progress.