Persistence of and interrelation between horizontal and vertical technology alliances

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René Belderbos, Victor Gilsing and Boris Lokshin

PERSISTENCE OF, AND INTERRELATION BETWEEN, HORIZONTAL AND VERTICAL TECHNOLOGY ALLIANCES

René Belderbos
Katholieke Universiteit Leuven, Leuven, Belgium,
Maastricht University and UNU-MERIT
E-mail: Rene.Belderbos@econ.kuleuven.be

Victor Gilsing
University of Tilburg, Centre for Innovation Research, The Netherlands
E-mail: V.A.Gilsing@uvt.nl

Boris Lokshin
Maastricht University and UNU-MERIT
P.O. Box 616, 6200 MD, Maastricht, The Netherlands
E-mail: B.Lokshin@os.unimaas.nl
(Tel: +31-43-3884430; fax: +31-43-3884905)

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ABSTRACT

We examine how and to what extent the propensity to be engaged in alliances with different partner types (suppliers, customers and competitors) depends on prior alliance engagement with partner firms of the same type (persistence) and prior engagement in alliances with the other partner types (interrelation). We derive hypotheses from a combined competence and governance view of collaboration, and test these on an extensive panel dataset of innovation-active Dutch firms during 1996-2004. We find persistence in alliance engagement of all three types of partners, but customer alliances are more persistent than supplier alliances. Most persistent are joint supplier and customer alliances, which we attribute to the advantages of value chain integration in innovation processes. Positive interrelation also exists in vertical alliances, as immediate past customer alliances increase the propensity to engage in supplier alliances and vice versa. On the other hand, while prior engagement in horizontal (competitor) alliances increases the propensity to engage in vertical alliances, this effect only occurs with a longer lag. Overall, our findings are highly supportive of the idea that alliance engagement with different partner types is heterogeneous but interrelated. Our analysis suggests that the inter-temporal relationship between different types of alliances may be as important as their simultaneous relationship in alliance portfolios.

PERSISTENCE OF, AND INTERRELATION BETWEEN, HORIZONTAL AND VERTICAL TECHNOLOGY ALLIANCES

INTRODUCTION

Already for over two decades strategic alliances and networks of inter-firm relations have been a ubiquitous phenomenon (e.g. Hagedoorn, 2002; Contractor and Lorange, 2002). There is a growing consensus in the literature that a firm's involvement in inter-firm technology alliances matters for its economic and innovative performance (Hagedoorn, 1993; Powell et al., 1996; Ahuja 2000a; Owen-Smith and Powell, 2004). Research on alliances has initially focused on the questions 'why' and 'when' alliances are formed (Duysters et al., 2001; Kogut and Zander, 1993; Powell and Brantley, 1992). Interdependence and resource complementarities have been addressed here as the most common explanation for the formation of inter-organizational ties (Richardson, 1972; Pfeffer and Nowak, 1976; Nohria and Garcia-Pont, 1991; Harrison et al., 2001). The literature has since broadened significantly and saw the emergence of two streams of research that have focused in particular on interrelationships between alliances of focal firms. The alliance network literature has focused on the question with which individual partner firms tie up, and the role of network embeddedness and network structural properties herein (e.g. Gulati, 1995a, 1995b; Gulati and Gargiulo, 1999; Chung et al., 2000). This literature has demonstrated that collaboration with specific partners tends to be highly persistent, but has abstracted from the role of partner attributes and resource complementarities. The alliance portfolio view, on the other hand, has focused on potential complementarities between alliances as they bring in different sets of knowledge or complementary capabilities (Lavie, 2007; Vassolo et al, 2004; Lokshin and Duijsters, 2008). This literature has shown that the role of partner

attributes is as important as the role of networks' structural properties (Lavie, 2007; Faems et al, 2005; Belderbos et al, 2004a).

Despite the broadening of the alliance literature and the notion that collaboration with different types of partners is driven by different motives and characterized by different risks and corresponding needs for control (Parkhe, 1993), little attention has been paid to the differences and interrelation between alliances with different partner types. Whereas the alliance portfolio view has examined how potential complementarities between different alliances affect firm performance, the literature has focused on specific subsets of partner attributes, such as their relative bargaining power (Lavie, 2007), degree of foreignness (Lavie and Miller, forthcoming; Lokshin and Duysters, 2008), or their specific technology domain (Vassolo et al, 2004). In this paper, we develop a broader view on differences in partner attributes by differentiating among partner types based on the different roles they play in complementing a firm's own resources and capabilities. More specifically, we distinguish between alliances with suppliers and/or customers (vertical collaboration) and alliances with competitors (horizontal collaboration), within a context of technological collaboration.

Vertical and horizontal collaboration are likely to serve different strategic purposes, which may carry differential implications for a firm's strategic proclivity to be engaged in each type of collaboration. Whereas vertical inter-firm relations are seen as spanning differentiated organizations that combine symbiotically to achieve collective ends, horizontal inter-firm relations span similar organizations that combine commensalistically to achieve collective ends (Baum and Ingram, 2002; Tidd et al., 2005). The objectives and performance effects of vertical alliances have also been found to differ from those of horizontal alliance with the latter frequently focusing on more radical innovations and the former on cost reduction or reduce time

to market (Belderbos et al, 2004a; 2004b; Tether, 2002). Although both types of collaboration have been subject of investigation in prior research, two streams of literature appear to have developed in relative isolation. In the literature on technology alliances, most studies have not made an explicit distinction between types of alliance partners or have restricted analysis to horizontal alliances within an industry (Hagedoorn, 1993; Mowery et al., 1996, 1998; Rowley et al., 2000; Ahuja, 2000a, 2000b; Hagedoorn and Duysters, 2002; Bae and Garguilo, 2003; Sampson, 2007). In contrast, the supply chain literature has largely focused on vertical alliances with suppliers or customers (Lee et al., 1997; Metters, 1997; Narashimhan and Jayaram, 1998; Rosenzweig et al., 2003; Vickery et al., 2003). Implicitly, both approaches assume that alliances with different types of partners are unrelated.

In this paper, we examine the persistence of, and interrelation between, engagement in alliances with the three different types of partners, with an application to technology alliances. We anticipate different propensities to be engaged, and persist, in collaboration with different partner types. This focus on the more strategic decision to engage in collaboration with a specific partner *type* complements the alliance network literature, which has examined the relationship between network characteristics and persistence but has focused on alliance formation with individual partner firms (e.g. Podolny, 1994; Gulati, 1995a, 1995b; Gulati and Gargiulo, 1999; Chung et al., 2000). Second, we contribute to the literature by specifically examining to what extent engagement in alliances with different partner types is interrelated, i.e. to what extent collaboration with one partner type enhances the propensity to be engaged in collaboration with another type. We argue that there are various reasons for such interrelations and in this way aim to contribute to a better understanding of dependencies across alliances with different partner types, an understudied subject in the literature until now (Lavie, 2007).

In order to understand persistence in, and interrelation between, engagement in technology alliances of these structural types, we combine competence and governance views of collaboration. Whereas a number of recent studies have combined both views in view of developing a more integrative theory of the firm that contributes to a better understanding of optimal firm boundaries (Argyres, 1996; Poppo and Zenger, 1998; Williamson, 1999; Leiblein and Miller, 2003; Jacobides and Hitt, 2005), this approach has not been applied to the analysis of strategic collaboration. While there has been a focus on the competence side in most of the alliance literature until now, the governance side has been recognized but remains understudied (Das and Teng, 2000; Reuer and Arino, 2002; Nooteboom, 2004a; Sampson, 2007). This is somewhat surprising as previous research has shown that interorganizational hazards are especially present in alliances involving technology (Gulati and Singh, 1998). Therefore, we argue that the combination of both views is required as they provide complementary perspectives on the strategic choices driving persistence of and interrelationships between alliances with different partner types.

We test hypotheses on a comprehensive panel dataset on innovating firms in the Netherlands, 1996-2004. We empirically examine the propensity of firms to be engaged in supplier, customer, and competitor alliances, and relate this to their engagement in these types of alliances in prior years. Persistence in this context is defined as the degree to which prior involvement in an alliance type predicts current involvement. This approach follows the definition of persistence as 'state dependence' (e.g. Heckman, 1981) and earlier work on the persistence in profits (Mueller, 1986), innovation (Raymond et al, 2009) or other measures of firm performance such as Tobin’s q (e.g. Villalonga, 2004). In contrast to most previous empirical work that relied on alliance press reports, we use official statistical survey data drawn

from the harmonized European Community Innovation Survey. An important advantage of this source is the fact that repeated observations are included on the same firms over longer periods (e.g. 6-10 years), making the data very suitable for analysis of persistence in alliance strategies. Another advantage is the diversity of firms included in the data: both large R&D intensive firms as well as small and medium sized enterprises are included, and the data cover a wide spectrum of industries. Hence, use of this dataset avoids the problem of oversampling of large firms and the lack of systematic information on alliance disbandment, which has hampered prior research using data on alliance announcements (Schilling, 2009). On the other hand, we note the limitations of this extensive longitudinal dataset in that it does not reveal identities of individual partner firms or the number of alliances of each type. For our purpose, the analysis of the propensity of alliance engagement with specific partner types, these drawbacks pose fewer problems.[1]

The paper proceeds as follows. The next section presents the theoretical framework and derives hypotheses. Section 3 describes the data, variables and methods. Section 4 presents the results and section 5 discusses the results and concludes.

THEORY AND HYPOTHESES

A competence view of collaboration draws on resource-based theory which emphasizes the development of valuable, rare, inimitable and non-substitutable resources as the basis for competitive advantage and superior innovation performance (Wernerfelt, 1984; Barney, 1991). The resource-based view has traditionally focused on a firm's internal resource base. It has been also recognized that external collaboration can contribute to the development of a unique resource base (Dyer and Singh, 1998; Teece et al., 1997; Eisenhardt and Martin, 2000;

[1] We discuss the limitations of the data and our approach in the concluding section.

Armstrong and Shimizu, 2007). Alliances enable firms to access and (re)combine external knowledge and to leverage complementary assets (Teece, 1992; Hagedoorn and Schakenraad, 1994; Powell et al., 1996; Das and Teng, 2000). Furthermore, a competence view of collaboration singles out the types of resources and capabilities that can be exchanged and possibly reconfigured by means of collaboration (Nooteboom, 2004a). Deployment of this perspective enables us to identify to what extent resources and capabilities as held by suppliers, customers and competitors differ in providing complementarity resources and capabilities to the focal firm and how this may carry implications for persistence of and interrelation between vertical and horizontal types of alliances. [2]

A complementary perspective is formed by a governance view of collaboration, which points to the role of collaborative hazards such as risks of undesirable knowledge spillovers and free-ridership in collaborative exchange of resources and capabilities. This may give rise to opportunism by partners, diminishing the possibilities to appropriate returns to innovation (Gulati and Singh, 1998; Nooteboom, 2004a; Lui and Ngo, 2004; Dhanaraj and Parkhe, 2006). Obviously, knowledge spillovers to competitors are considered far more risky than to suppliers and/or customers (Ahuja, 2000a). A governance view sheds some more light on the extent to which partner types differ in their risk profiles, which will carry implications for persistence of and interrelation between horizontal and vertical alliances.

In developing our hypotheses, we draw on these two theoretical frameworks. We first develop a baseline hypothesis on the persistence of collaboration with each specific type: with suppliers, customers or competitors. We then develop hypotheses that specify to what degree

[2] Although we argue that firms engage in persistence of alliance strategies because it brings certain strategic benefits, this does not imply that such persistence will always carry positive performance effects. As recently demonstrated, there may also be a downside to persistence in collaboration in case the external environment changes in radical ways (Koka and Prescott, 2008).

persistence differs between alliances with different partner types as well as on how engagement in alliances with one partner type affects the propensity to be engaged in alliances with another partner type.

Baseline hypothesis: persistence of supplier, customer and competitor alliances

Collaboration with *suppliers* can help firms achieve competitive advantage by realizing higher process efficiencies (Saeed et al., 2005) and by reducing costs and increasing the speed of implementing new product introductions (Eisenhardt and Tabrizi, 1994). Moreover, collaboration with suppliers enables a firm to maintain its focus on strengthening core competences and technology development, and to secure access to key inputs (Suzuki, 1993; Kamath and Liker, 1994). Collaboration may also create additional opportunities for the build-up of valuable, specific and difficult to imitate resources and competences, shared between a firm and its suppliers (Tidd et al., 2005). This may provide a focal firm with an opportunity to direct suppliers' development efforts and shape their (technological) competences (Ragatz et al., 1997). Furthermore, by engaging in collaboration with suppliers, a focal firm can also build up a strong reputation as a reliable and attractive partner to suppliers, thus reducing the risk of opportunistic behavior and negative referrals or lock-out from future collaborative opportunities (Ireland et al., 2002; Nooteboom, 2004b). Through these processes, collaboration with suppliers is likely to provide a focal firm with additional opportunities for collaboration with existing and/or new suppliers, increasing its propensity of engagement in technology collaboration of this type. Overall, these arguments suggest persistence of collaboration with suppliers.

Collaboration with *customers* may enable firms to source leads on new or adapted products and to reduce risks of uncertainty associated with market introduction of new products

(von Hippel, 1988; Schmookler, 1966). In this way, collaboration with customers may be essential in ensuring market expansion when input by customers for introduction of new products and/or adaptation of existing products is required (Littler, Leverick and Bruce, 1995; Tether, 2002). For customers, such collaboration may be attractive because they may be able to steer the development of competences and routines within the focal firm to their advantage (Ragatz et al., 1997). For the focal firm, alliances with customers may provide it with a better understanding of its customers' current needs and/or future (unmet) needs (Aaker, 1996; Tidd et al., 2005). In particular if customers are lead-users, their needs may be indicative of a (large) future mass market (Von Hippel, 1988). The more a focal firm replicates ties with customers, the more it can build up shared and unique capabilities that are required for the realization of shorter lead times, improved quality and greater flexibility, resulting in improved efficiency, innovativeness and market responsiveness (Choi and Hartely, 1996; Fisher, 1997; Childerhouse et al., 2002; Rosenzweig et al., 2003; Tidd et al., 2005). In addition, the general argument holds that by engaging in collaboration with customers, a focal firm can develop and nurture capabilities to collaborate with this type of partner and to build up a strong reputation as a reliable and attractive partner (Ireland et al., 2002; Duysters et al., 2007a; 2007b). This is likely to provide a focal firm with additional opportunities for collaboration with existing and/or new customers, increasing its propensity to be engaged in this type of collaboration. These arguments suggest persistence of collaboration with customers.

In line with the commensalistic nature of the collaboration, technology alliances with *competitors* tend to focus on research trajectories that precede application in the competitive arena (Baum and Ingram, 2002). In this way, horizontal collaboration may contribute to a firm's future competitiveness in domains that are currently non-core. Research consortia, for example,

fall into this category where competitors work together in order to share the costs and risks of research, pool scare expertise and equipment and aim to develop far-from-market technology with generic application potential (Miotti and Sachwald, 2003; Tidd et al., 2005). Although the realization of a completely new technology may require a longer time horizon, firms can reap collaborative benefits immediately by learning from their competitors' specific expertise (Sampson, 2007). To this end a sufficient degree of trust is required that facilitates the exchange of more tacit knowledge and reduces the risk of hold-up and free-ridership that may be present in horizontal collaboration (Park and Russo, 1996; Nooteboom, 2004b; Fey and Birkinshaw, 2005). Collaboration with competitors may signal that a company is not only technologically competent but also trustworthy (Lui and Ngo, 2004). In addition, collaboration with competitors enables a focal firm to develop and nurture capabilities to collaborate with this type of partner and to gain a reputation of being experienced and reliable in horizontal collaboration (Ireland et al., 2002; Duysters et al., 2007a; 2007b). This suggests persistence of collaboration with competitors, as prior collaboration increases the opportunities to the focal firm for future collaboration with existing and/or new competitors.

The above arguments suggest persistence of technology collaboration with each type of partner, i.e. suppliers, customers and competitors. This leads to our baseline hypothesis:

Hypothesis 1: Previous engagement in alliances with a specific type of partner (customer, supplier, and competitor) increases the propensity to be engaged in alliances with that type of partner.

Differences in persistence between supplier and customer alliances

When considering vertical collaboration more in-depth, we anticipate persistence of collaboration with customers to be stronger relative to collaboration with suppliers. Here, a competence perspective suggests that demand-pull forces tend to be more important as determinants of innovative activities (Dosi, 1988; Dosi et al., 1990; Von Hippel, 1988). When suppliers are engaged in the innovation process, a more temporary and sometimes ad-hoc type of collaboration may be more appropriate, with a clearly focused and project-based form (Andersen, 1999). Collaboration with customers is generally considered to be useful throughout the entire innovation process (Dosi, 1988; Von Hippel, 1988). This applies both to its early phases in which collaboration with lead users can provide firms with access to novel ideas that may be indicative of a (large) future market (Von Hippel, 1978) and to its later phases with their emphasis on gaining market acceptance for the new innovation and stimulating its wider diffusion (Dosi et al., 1990; Tidd et al., 2005). This suggests stronger persistence of customer collaboration in comparison with supplier collaboration.

From a governance perspective, collaboration with suppliers may lead these to become more qualified and hence more attractive as partners to competitors, potentially enabling the latter to free ride on the investments made by the focal firm (Park and Russo, 1996; Nooteboom 2004a; Mesquita et al., 2008). Although this risk can be reduced by partnership exclusive arrangements and relational governance between the focal firm and its supplier(s) (Zaheer and Venkataraman, 1995; Mesquita et al., 2008), this may not be sufficient to enhance persistence of collaboration with suppliers. For a focal firm, an increasing dependence on collaboration on, and risk of knowledge spillovers through, suppliers will increase the inclination to consider alternatives to collaboration, such as internal procurement and market procurement (Gulati et al.,

2005). Hence, whereas persistence of collaboration with suppliers may be attractive for the focal firm, the risk of spillovers and its corresponding remedial measures may reduce this propensity. Although the risk of spillovers can also be present in collaboration with customers, these may be outweighed by the strategic value of access to (scarce) information on specific customer needs and the higher likelihood of initial market acceptance and (future) commercial success.

Both from a competence and a governance perspective, the above arguments suggest stronger persistence of customer collaboration when compared with supplier collaboration, leading to our second hypothesis.

Hypothesis 2: Engagement in customer alliances is more persistent than engagement in supplier alliances.

The relationship between supplier and customer alliances

Supplier and customer alliances engagement are also likely to be interrelated. Vertical collaboration with suppliers and customers implies the bridging of three value steps along a value chain. By its nature, a value chain entails a highly systemic division of labor where change in one value step may have far-reaching implications for adjacent value steps – upstream and/or downstream (Porter, 1980). As a consequence, new product innovations or process improvements need to be well coordinated in order to mitigate risks of (major) inconsistencies across two or more value steps as well as to ensure their timely commercialization and/or implementation (Diez-Vial, 2007). In addition, vertical collaboration may also facilitate the reduction or elimination of operational inefficiencies along a value chain such as, for example, those resulting from 'bullwhip' effects due to demand variability (Metters, 1997; Lee et al.,

1997; Gulati and Sytch, 2007). In this way, collaboration with both types of chain partners supports firms to develop product innovations and/or implement process improvements in a more rapid, cost effective and integral manner (Choi and Hartely, 1996; Fisher, 1997; Childerhouse et al., 2002; Rosenzweig et al., 2003). Accomplishing these objectives induces a need for firms to act in tune. This may be realized by creating a degree of alignment between collaboration with suppliers and customers. Such alignment implies that alliances with suppliers and customers are not pursued in isolation but rather that collaboration with one type leads to collaboration with the other.

The strongest alignment can be achieved through simultaneous vertical collaboration with suppliers and customers, and this may carry additional advantages. It offers the possibility for direct knowledge exchange and real-time coordination among all three types of partners. This further reduces the risk of inconsistencies across value steps, improves efficiency by elimination of duplicative efforts and decreases chances of misunderstanding. In addition, it allows for the exchange of more specific, fine-grained information that may contribute to the build-up of shared innovation-based capabilities and routines that become difficult to imitate for others (Ragatz et al., 1997). Through simultaneous collaboration, suppliers may get more exact information on specific needs of their customers' customers, which is critical for the successful realization of product innovations (Echols and Tsai, 2005). In addition, such information may enable suppliers to allocate scarce resources more efficiently to those domains that carry clear commercial potential. Likewise, from the perspective of customers, collaboration with the focal firm may secure access to vital knowledge and specialized capabilities as held by key suppliers that cooperate with the focal firm. In this way, suppliers and customers may form an important

(indirect) source of information and of economic value to each other, making simultaneous collaboration also attractive from their point of view.

Combining collaboration with suppliers and customers may also be attractive from a governance perspective. The connection that the focal firm forms between its suppliers and customers reduces room for conflict and opportunism as it offers the possibility of threatening to pass on information on opportunistic behavior to the other partner(s). Reduced risks of conflict and relational hazards increase stability of the collaboration and provide a basis for the build-up of trust (Nooteboom, 2004b). This solidifies vertical coordination and knowledge exchange, which increases the likelihood that shared innovation-based capabilities and routines remain difficult to imitate (Gulati and Sytch, 2007). In this way, simultaneous vertical collaboration can yield a continuous supply of new opportunities for innovation and value creation, securing competitive advantage in core domains (Porter, 1980; Dyer and Singh, 2000; Priem and Butlers, 2001; Gulati and Sytch, 2007). This is consistent with the finding in the operations management literature suggesting that firms persistently engaging in vertical, value chain spanning collaboration with suppliers and customers can achieve superior performance (Narasimhan and Jayaram, 1998; Vickery et al., 2003; Frohlich and Westbrook, 2001; Rosenzweig et al., 2003).

Based on the above arguments, we arrive at two predictions regarding the relationship between suppliers and customers alliances. First, the benefits of alignment between supplier and customer collaboration suggest that firms that have been engaged in an alliance with one of the chain partners will have a greater propensity to be engaged in collaboration with the other vertical chain partner. Second, the advantages of joint supplier customer collaboration suggest that firms that are engaged in simultaneous collaboration with suppliers and customers have strong reasons to persist in such joint collaboration. The advantages relative to pursing one type

of collaboration in isolation suggest that this persistence is greater than persistence in alliances with suppliers or customers. This leads to the following two hypotheses:

Hypothesis 3: Previous engagement in supplier alliances increases the propensity to be engaged in customer alliances, and vice versa.

Hypothesis 4: Simultaneous engagement in alliances with suppliers and customers is more persistent than engagement in alliances with suppliers *or* customers.

The relationship between horizontal and vertical alliances

Vertical collaboration is generally considered to be particularly well suited for deepening existing competences and optimizing an established value chain (Tripsas, 1997; Brown and Eisenhardt, 1995). In this way, vertical collaboration offers room for the build-up and strengthening of competitive advantage in core domains, such as new product innovations, reduced development time and efficiency gains. However, it is considered to be less well suited for the creation of new, state-of-the-art technology (Tidd et al., 2005). For that purpose, horizontal alliances are likely to be better equipped given their general focus on pre-competitive development of far-from-market technology with wide(r) application potential (Teece, 1980; Hagedoorn, 2002; Belderbos et al., 2006; Tether, 2002; Miotti and Sachwald, 2003). This may form the basis for a focal firm's future competitive advantage in non-core domains, securing continuity on the long term. Prior studies on the performance effects of alliances with different partner types has confirmed that alliances with competitors are often most effective for the

generation of new-to-the-market products, while supplier and customer alliance tend to impact on productivity growth and product improvements (Belderbos et al, 2004a; Faems et. al, 2005).

A competence perspective suggests substantial benefits of combining horizontal and vertical technology collaboration strategies. Horizontal technology-based collaboration may provide firms with access to scarce, external expertise on promising new technologies, and allow for the exchange of knowledge between partners that stimulate learning and facilitate its further recombination (Ahuja, 2000b). Such recombinatory efforts may lead to the creation of technologies with a high novelty value, yielding potential to generate future revenue streams (Sampson, 2007; Gilsing et al., 2008). However, to realize such future business opportunities requires successful commercialization and/or implementation of the newly created technology. Vertical collaboration with suppliers and/or customers is generally better suited for that purpose (Choi and Hartely, 1996; Fisher, 1997; Childerhouse et al., 2002; Rosenzweig et al., 2003; King et al., 2003; Tidd et al., 2005), and can usefully complement horizontal collaboration.

In contrast, a governance view on collaboration highlights the risk of undesirable knowledge spillovers and free-ridership, especially in case of collaboration with competitors. Due to comparable knowledge bases and competences, competitors may have a greater capacity for absorption and appropriation of knowledge spillovers, creating a temptation for free-ridership (Park and Russo, 1996; Khanna et al., 1998; Nooteboom, 2004b; Phelps, 2009). This also implies that simultaneous horizontal and vertical collaboration increases the likelihood that specific knowledge of a focal firm, as developed with its customer(s) and/or supplier(s), may spill over to its horizontal partners. Since horizontal partners are likely to figure as a firm's (future) competitors in downstream markets, knowledge spillovers may erode its competitive advantage

(Ahuja, 2000a). In particular if the technology alliance is in the focal firm's core domains, this may severely damage its competitiveness and threaten its short term profits.

In sum, a governance perspective suggests important risks and drawbacks of combining vertical and horizontal technology alliances, while the competence perspective highlights the potential complementarity between the two strategies. However, the arguments above also suggest that the two perspectives can perhaps be reconciled. The governance risks are foremost an issue if the two types of collaboration overlap in time, such that the focal firm functions as the bridge between competitors and vertical partners. At the same time, the positive relationship suggested by the competence view leaves open the possibility of reaping the benefits by combining horizontal and vertical collaboration in a more consecutive manner. Established insights from the innovation and (product) life cycle literature provide such arguments for consecutive alignment benefits where it concerns the transition from horizontal to vertical alliances.

In this literature, it is argued that an initial focus on exploration, with its emphasis on creativity and small-scale experimentation, makes room for a focus on exploitation characterized by a focus on efficiency and (large scale) commercialization (Abernathy and Clark, 1985; Abernathy and Utterback, 1978; Anderson and Tushman, 1990). Seen in this light, horizontal alliances may be particularly well suited for exploration while vertical alliances may be considered as especially useful for exploitation. The literature on exploitation and exploration has suggested that these may then be optimally combined through a 'punctuated equilibrium' strategy, combining exploration and exploitation through some form of temporal separation between the two activities (Burgelman, 2002; Levinthal and March, 1993; Gupta et al., 2006). In contrast, the alternative strategy of 'ambidexterity' formed by organizational separation between

the two activities at the same point in time will not mitigate the governance risks of combining the two types of alliances (Burgelman, 1991; Gupta et al., 2006). Moreover, temporal separation does not need to be harmful from a competence perspective. On the contrary, it can enhance the explorative nature of horizontal collaboration by providing seclusion from current markets and established practices. In this way, more room is offered to maneuver and experiment freely and to obtain novel inspiration and insights from new and disruptive developments that typically emerge beyond the boundaries of an established industry (Geels, 2003). Simultaneous collaboration with customers and/or suppliers in this case may hamper this and may increase the risk of missing out on such newly emerging key trends in new technologies (Gilsing, 2005).

The transition from exploration to exploitation occurs once the new technology has been developed and prototypes start to become available, after which the phase of commercialization starts. This tends to be a lengthy and rather complex process as (new) customers need to become involved and a (new) supply chain needs to be developed (Hobday et al., 2000). The more radical or disruptive the new technology, the more important subsequent involvement of customers and/or suppliers becomes and the more collaboration shifts from regular partnerships to processes of intensive co-development (Dewar and Dutton, 1986; Bozdogan et al., 1998; Callahan and Lasry, 2004).

Overall, the arguments above suggest that engagement in horizontal collaboration will increase the propensity to engage in vertical collaboration over time. This intertemporal relationship will be characterized by a sufficient lag between the two alliance strategies in order to allow for a sequence of discovery and experimentation in horizontal collaboration followed by upscaling and commercialization in vertical collaboration. In addition, this lag must not be too long for sacrificing many of the competence-based benefits but should be sufficient to mitigate

governance risks. These considerations on intertemporal relations between horizontal and vertical alliances do not play a role in the case of interrelation between supplier and customer alliances. In contrast, a longer lag in this case can cause a delay that inhibits the alignment of collaboration with suppliers and customers that is required for accomplishing the strategic objectives of vertical collaboration. Hence, the arguments above predict that compared with the supplier-customer alliance interrelationship (cf. Hypothesis 3), the effect of prior horizontal alliance engagement on the propensity to engage in vertical alliances is subject to a greater delay. This leads to our final hypothesis:

Hypothesis 5: Previous engagement in alliances with competitors increases the propensity to be engaged in alliances with suppliers and/or customers, but with a longer lag compared to the interrelationship between supplier and customer alliances.

DATA AND METHODS

The empirical analysis uses a panel data set constructed from five consecutive European Community Innovation Surveys (CIS) conducted in 1996, 1998, 2000, 2002 and 2004 by the Central Bureau of Statistics (CBS) in the Netherlands. The sampling methodology and the harmonized questionnaire are described in the OECD Oslo Manual (OECD, 1997).[3] It has been only recently that researchers have been able to utilize consecutive CIS surveys, allowing the investigation of persistence in technological collaboration. The CIS surveys contain data concerning R&D expenditures and innovation activities of the firm, and engagement in collaborative technology development distinguished by partner type. The technology alliances in

[3] See also Laursen and Salter (2005) for a discussion of the UK version of Community Innovation Survey.

the survey relate to joint development efforts and collaboration on R&D, and can be seen as representing stronger forms of interaction between the firms, The CIS surveys are sent to all large firms and to a random sample of smaller firms comprising ten or more employees. The surveys contain the full range of questionnaire items for these firms indicating that they are active in innovation. The sample of innovation active firms across a wide range of industries and firm sizes is an appropriate one for our study. Since we are interested in the persistence of technology alliances, our analysis naturally is confined to firms engaging in innovative activities for which technology collaboration is relevant. We created the panel data set by merging the records of the innovation active firms in the five consecutive surveys, using the identification code of establishments from the Central Bureau of Statistics. The panel data set includes 4632 on 3181 innovating firms from a wide range of sectors. Each firm is observed at least in three consecutive survey years, as this is required to examine persistence in our empirical model. Given the partially random sampling in each year for smaller firms, we do not often observe each firm for the entire period (1996-2004) and the panel is unbalanced in nature. A subset of 300 firms is covered in the surveys in each of the years, i.e. data for all the variables used in the estimation are available in 5 surveys for a total of 10 years. For 851 firms data are available in 4 consecutive surveys for a total of 8 years and 2030 firms are observed in 3 surveys for a total of 6 years. In the empirical analysis the following industries are used with their standard industrial classification code (NACE) in parentheses: food, beverages and tobacco (15-16), textile, apparel and leather (17-19), Paper and paper products (21), printing (22), Oil (23), chemicals and pharmaceuticals (24), rubber products and plastics (25), non-metallic products and basic metals (26-27), fabricated metal products (28), machines and equipment (29), electrical products (30-

33), motor vehicles (34-35), other manufacturing (36-37), construction (45), wholesalers and repair 50-52), communication services (60-64), and business services (70-74).

Variable construction

The CIS surveys ask the question if the firm had any cooperation arrangements on innovation activities with other firms in the last 2 years. Cooperation agreements are then differentiated by the type of partner such as customers, suppliers, and competitors. Based on this question, we create three dependent variables taking the value one if a firm reported to be engaged in a particular type of alliance, i.e. customer, supplier or competitor, and zero otherwise[4]. We also construct as a dependent variable 'joint customer and supplier alliance', taking the value one if the firm engaged in both these types of alliances in order to test for Hypothesis 3, for which we estimate a separate model. We define persistence as the degree to which prior involvement in alliances with a specific partner type predicts current involvement in such alliances. This approach follows the definition of persistence as 'state dependence' (e.g. Heckman, 1981), which in our context means that being engaged in past alliance activities increases the probability to be engaged in these activities currently. A similar approach has been used to analyze persistence in profits (Mueller, 1986), innovation (Raymond et al, 2009) or other measures of firm performance such as Tobin's q (Villalonga, 2004): in these studies the 'current state' of a firm (in terms of strategy or performance) is similarly related to 'past states' in the same dimension to establish persistence. We examine persistence and interrelation by including as covariates dummy variables for past technology alliances, measuring engagement in technology alliances as reported in the previous surveys conducted two and four years earlier.

[4] It is possible that especially large firms have multiple technology alliances of a particular alliance type. The CIS surveys however do not contain information on the number of alliances per type.

While the coefficients on prior involvement in the same type of alliance indicate persistence, the coefficients on prior involvement in the other two types of alliances indicate interrelation. In case of the analysis of joint supplier and customer collaboration (Hypothesis 3), the past 'state' indicating persistence is past engagement in supplier and customer alliances jointly. To examine interrelation in this model, we include, in addition to past involvement in competitor alliances, past engagement in single alliance strategies with customers or suppliers (alliance with customers but not with suppliers, and vice versa). This avoids overlap with the persistence effect of supplier-customer strategies as these variables are orthogonal to joint supplier and customer alliances.[5] At the same time, it allows examining the transition from partial vertical alliance strategies (collaboration only with customers or only with suppliers) to integrated vertical alliance strategies.

As control variables, we include R&D intensity (the share of R&D employees in total employment) and its squared term. R&D engagement increases a firm's capacity to recognize, value and assimilate external knowledge from alliance partners (Cohen and Levinthal, 1990; Kim, 1998; Mowery and Oxley, 1995). In this way, more R&D-intensive firms are also more likely to engage in several technological collaboration projects but with diminishing propensity (Belderbos et al, 2004b). The analysis also controls for firm size. The literature indicates that the size of companies plays a role in propensity to be engaged in collaboration. Larger firms have more abundant resources and may find it less problematic to handle multiple innovation objectives and management of multiple technology collaborations (e.g. Belderbos et al., 2006; Cohen and Klepper, 1996; Harrigan, 1988). We include the logarithm of the number of employees. R&D intensity and firm size are taken from the (t-2) survey. We also include firm

[5] Since we do not examine interaction effects, we avoid the issue of calculating cross derivatives in nonlinear models such as probit (e.g. Hoetker, 2007; Ai, and Norton. 2003).

age. Older companies tend to be more experienced and will have well-established routines in place (Nelson and Winter, 1982; March, 1988), also specifically geared to collaboration, which may positively affect their propensity to be engaged in collaboration. On the other hand, well-established routines and abundant experience may also make that firms tend to become more self-reliant (Tidd et al., 2005), which reduces their propensity to be engaged in external collaboration. Furthermore, we control for whether the firm is an affiliate of a foreign multinational firm or part of a larger (domestic grouping). Firms that are part of a larger group may draw on group financial and technological resources and reputation to make them more attractive as cooperation partners and to support collaborative efforts (e.g. Ahuja, 2000). At the same time such firms may have fewer incentives to cooperate with outside partners, as they are likely to have intra-group R&D collaboration opportunities.

Finally we include a set of time dummies, industry dummies at the ISIC-2 level as the need for technology collaboration and the use of particular alliances types may differ across industries and across years, and eleven region (province) dummies as the opportunity for collaboration arising from, for instance, differences with regard to innovation activity or clustering of suppliers may vary systematically across locations (e.g., Audretsch and Feldman, 1996; Fritsch, 2004).

Descriptive Statistics

Table 1 provides the variable definitions and their descriptive statistics and Table 2 lists correlations between the variables used in the estimation. Table 1 indicates that supplier collaboration is most frequently adopted, with 13.1 % of the cases, followed by customer collaboration (10.1 %) and competitor collaboration (6.6 % cases). In addition, 8.3% of the firms

are engaged in both supplier and customer collaboration, indicating a relatively frequent use of such combined supplier and customer alliances. The percentages are comparable for current and past alliances. The R&D intensity of the firms in the sample is on average 3.1 percent. The correlation table (Table 2) indicates the highest correlation between concurrent supplier and customer variables (69%), a much smaller correlation between current and lagged alliances, and a positive but small correlation between vertical and horizontal alliances. Firm size and R&D are positively correlated with alliances with each partner type. The table does not indicate multicollinearity problems for the set of independent variables, Apart from the naturally high correlation between R&D and its square term and the negative correlation between the orthogonal group affiliation and MNE affiliation dummies, the highest correlation coefficient is 0.59.[6]

Insert table1 about here

Insert table2 about here

Empirical Methods

In order to analyze the determinants of the propensity to be engaged in collaboration with the three types of partners, we estimate a multivariate probit model with the dummy variables 'competitor alliance', 'customer alliance' and 'supplier alliance' as dependent variables. The error terms of the three individual probit equations are likely to be correlated if firms are simultaneously considering decisions to engage in the three types of alliances. Use of the

[6] We also examined multicollinearity through the condition number of the matrix of regressors. This statistic (the ratio of largest to smallest eigenvalue) is an unbounded measure of collinearity, or ill-conditioning, in the data (Belsley, 1991). These diagnostic measures did not indicate problems of collinear regressors in our models.

multivariate probit model in which we simultaneously estimate the propensity to be engaged in collaboration with the three partner types addresses this problem and leads to an improvement in the efficiency of the estimates.

Given that we analyze unbalanced panel data, we also estimated probit equations for each alliance type using panel probit estimators with random effects.[7] The estimates from these individual equations are consistent, albeit not efficient because they do not take correlation between equations into account. We used likelihood ratio test to test the significance of the panel-level variance component (rho) in the total variance. In the customer and competitor equations we could not reject the null hypothesis that rho is zero at any conventional level. In the supplier equation the null hypothesis could not be rejected at the 5 percent level but was just rejected at the 10 percent level. Overall, these results indicate that the panel-level variance component is only of marginal importance and that the pooled multivariate probit estimators are to be preferred over the random effects estimator. The implication is that we could proceed by estimating the equations as a multivariate probit system. The system of equations is given in equation (1).

$$y_{it,k} = \begin{cases} 1 \, if \; \beta_{1,k} CUS_{it-2,k} + \beta_{2,k} CUS_{it-4,k} + \beta_{3,k} SUP_{it-2,k} + \beta_{4,k} SUP_{it-4,k} + \beta_{5,k} COM_{it-2,k} + \beta_{6,k} COM_{it-4,k} \\ + \mathbf{Z}_{it-2,k} \theta_k + \omega_{it,k} > 0 \\ 0 \, otherwise \end{cases}, \qquad k = 1,...,3; i = 1,...,N; t = 1,...,5 \tag{1}$$

where *i* indexes firms and *t* years, accordingly; $y_{it,1}$, $y_{it,2}$, and $y_{it,3}$ are the binary indicators which take the value one if a firm reported to be engaged in an alliance with customers, suppliers and competitors, respectively, and zero otherwise. CUS, SUP, and COM measure alliance

[7] Fixed effects probit estimator produces inconsistent estimates due to so called 'incidental parameters problem' (Green, 2002; Wooldridge, 2002, p. 484).

engagement in the previous two surveys: t-2 refers to the survey 2 years before and t-4 refers to the survey 4 years before. The size and significance of the coefficients on the past alliance for the same type variables indicate how persistent alliances with each partner type are. Specifically, Hypothesis 1 predicts that past (t-2, t-4) CUStomer, SUPplier, and COMpetiror have a positive impact on engagement in the same alliances at time t. Hypothesis 2 predicts that the t-2 and t-4 past alliance engagement coefficients are larger in the customer equation than in the supplier equation. Hypothesis 3 predicts a positive effect of past CUStomer on current SUPplier alliances, and past SUPplier on current CUStomer alliances. Hypothesis 5 predicts a primarily lagged effect (t-4) of COMpetitor on SUPplier and CUStomer alliances.

The error term ω_{it} in equation 1 is assumed to be random in each of the three equations, and the vector **Z** contains our control variables. The coefficients to be estimated, $\beta_{1,k}$ through $\beta_{6,k}$, are not constrained across the three equations, but the model allows us to test whether the determinants of the propensity to form alliances of each type are significantly different across equations.[8]

In order to test for persistence of joint supplier and customer technology alliances (Hypothesis 4), we estimated a separate probit model with this joint collaboration as a dependent variable. It is not possible to estimate this supplier-customer equation jointly with the single alliance equations in the multivariate probit model because the dependent variable is a function of two other dependent variables in the model (customer alliances, supplier alliances).

An important issue in the empirical analysis is potential endogeneity biasing our results. It has been noted that this type of selection bias is of particular importance in performance

[8] We use the GHK simulated maximum likelihood estimator; results are obtained with a Stata CMP routine. Hajivassiliou et al. (1996) prove that under regularity conditions the simulated maximum likelihood estimator is consistent when both the number of draws and observations goes to infinity

studies since managers' decisions are endogenous to their expected performance outcomes (Hamilton and Nickerson, 2006; Leiblein et al; 2002; Shaver, 1998). In the context of our analysis, it is possible that some unobserved firm specific factors affect the propensity to be engaged in alliances and/or specific alliance types, such that firms are 'selected in' alliance engagement. The effect of past engagement in alliances with specific partner types on the current probability to be engaged in alliances with specific partner types then could in theory be a corollary of this selection effect rather than a real persistence effect. In our analysis, we expect this bias to be limited or non-existent, for a number of reasons. First, potential selection effects due to unobserved heterogeneity are mitigated by the use of a wide set of firm-specific control variables that affect the propensity to be engaged in specific alliance types. Second, while a remaining selection effects cannot be ruled out, this may potentially lead to an upward bias in the persistence effects, but it is not evident why it would lead to systematic *differences* in persistence across alliance partners, nor is it evident that this should affect patterns of interrelation between alliance engagement with different partners. The latter are the core hypotheses of our paper. Third, one would expect that estimation with firm individual effects would control for the relevant unobserved firm characteristics that may drive longer term selection into alliance types. As we note in the paper, tests of random effect estimators show that these random effects are jointly insignificant (the random effects model is rejected in favor of the multivariate probit), again suggesting that unobserved heterogeneity leading to selection is not likely to bias our results.

EMPRICAL RESULTS

Table 3 reports the results from the multivariate probit explaining the propensity of firms to be engaged in technology alliances with the three types of partners. Table 4 contains the results of a separate probit model explaining the propensity to be engaged in value chain spanning vertical alliances (supplier and customer alliances combined).

A first observation from Table 3 is that the correlation coefficients of the error terms in the multivariate probit model (Rho) are positive, ranging from 0.5 to 0.8, and highly significant. This supports the notion of interdependence between the decisions to be engaged in collaboration with different partner types and confirms the need to use the simultaneous equations approach.

Insert table 3 about here

The coefficients on the corresponding past alliance variable for t-2 (listed on the diagonal of Table 3) are highly significant in each of the three equations. In addition, the coefficient on (t-4) is significant in the customer and competitor equations, but not in the supplier equation. These results corroborate hypothesis 1: previous engagement in alliances with a specific type of partner (customer, supplier, and competitor) increases the propensity to be engaged in alliances with that partner type. The results indicate that collaboration with each of the three partner types is persistent, but in different degrees. Specifically, our findings provide evidence for hypothesis 2. Past customer alliances at both t-2 and t-4 affects current engagement in customer collaboration, whereas for suppliers this only applies to t-2. We tested this more formally: a Wald test rejects ($p<0.01$) the null hypothesis that the sum of the coefficients on the t-2 and t-4 own lagged terms in the customer and supplier equations, respectively is equal.

The results in Table 3 also show positive interrelation effects between supplier and

customer cooperation. Supplier alliances in t-2 have a significantly positive impact on the propensity to be engaged in customer alliances, and vice versa. In addition, past customer alliances in t-4 have an additional positive impact on engagement in supplier alliances, while there is no significant effect of supplier alliances (t-4) on customer alliances. These results support hypothesis 3, which stated that previous engagement in supplier alliances increases the propensity to be engaged in customer alliances, and vice versa. In addition, there is additional evidence in support of hypothesis 3 in the equation with *joint* supplier and customer alliance engagement as the dependent variable (Table 4). Here past (t-2) alliance engagement only with customers or only with suppliers has a positive impact on simultaneous engagement in alliances with suppliers and customers. In addition, t-4 engagement in only customer alliances positively affects the propensity of engagement in current joint customer-supplier alliances. Hence, firms engaged in supplier (customer) collaboration are likely to add customer (supplier) cooperation in a subsequent period. These results again show a positive interrelation between alliances with both partner types, with overall the strongest and consistent impact found for recent past alliances (t-2).

The results in Table 4 also provide support for Hypothesis 4. The results of the probit model explaining engagement in vertical alliances (joint customer and supplier alliance) show that past engagement in joint collaboration in both t-2 and t-4 has a positive and highly significant ($p<0.01$) impact on current engagement in vertical collaboration. The coefficients on the past joint terms suggest that their combined effect is 20-30 percent higher than the combined effect of the t-2 and t-4 coefficients measuring persistence of individual alliances with suppliers or customers in Table 3. We tested this difference formally using Wald tests (e.g., Clogg et al., 1995). A two-sided test rejected the null hypothesis of equivalence of the coefficients in the

customer equation (Table 3, column 1), the supplier equation (Table 3, column 2) and the competitor equation (Table 3, column 3) with p-values < 0.01. Overall, these results provide strong support for Hypothesis 4, which predicted simultaneous engagement in alliances with suppliers and customers to be more persistent than engagement in alliances with only suppliers or only customers.

Turning to the test for Hypothesis 5, the results show that recent past (t-2) competitor alliances (t-2) have no impact on the propensity to be engaged in supplier or customer alliances (Table 3), nor on the propensity of engagement in supplier and customer alliances simultaneously (Table 4). In contrast, if we examine past alliances with a longer lag (t-4), the results do show a significant impact of past competitor alliances on the propensity to be engaged in alliances with suppliers or customers (Table 3), as well as on engagement in alliances with suppliers and customers simultaneously (Table 4). These results all provide strong support for Hypothesis 5: past engagement in alliances with competitors increases the propensity to be engaged in alliances with customers and suppliers, but this interrelation effect only occurs with a longer lag (t-4) when compared to the interrelationship between collaboration with suppliers and customers (which is strongest for t-2). In sensitivity tests, we also examined the impact of an even longer lag between horizontal and vertical alliances, including the variable horizontal alliance engagement in t-6. Such a test requires data on firms in four consecutive surveys, and this more than halves our sample given the underlying sampling process. Competitor collaboration in t-6 was not significant in any of the equations, while the positive and significant coefficients of horizontal alliance engagement in t-4 remained robust. Hence, the empirical regularities seem to point to an effective lag of roughly 4 years.

The empirical results also show additional positive effects of past customer alliances with a

longer lag (t-4) and of recent past supplier alliances (t-2) on the propensity to be engaged in competitor alliances. Although the literature did not provide specific guidance on the interrelation from vertical to horizontal collaboration, these are interesting findings to which we will return when discussing avenues for future research.

Among the control variables, firm size is positive and significant in each of the equations. The effect of R&D intensity on the propensity to be engaged in technology alliances is curvilinear in all equations, with a declining marginal impact for high R&D intensities. Age carries a small, negative effect that may reflect a decreasing propensity to be engaged in external, innovation-based collaboration when firms age. Firms that are part of a foreign multinational or a domestic group generally have a greater propensity to be engaged in alliances. Location also matters: the likelihood-ratio test rejects the constrained specification in which location (province) dummies are jointly set to zero, in favor of the specification with the province dummies (LR = 510.83, p-value< 0.001).[9] In addition, the time and industry dummies (not reported) are jointly significant: the likelihood-ratio test rejects the constrained specification, in which time and industry dummies are jointly set to zero, in favor of the specification with the dummies (LR = 618.42, p-value<0.001)[10]. To test whether there are also differential effects of the past alliance variables between manufacturing and service firms, we applied a Chow test (e.g., Gujarati, 2005, p. 275) by including 6 interaction effects in each equation between a service dummy and the past alliance strategies. The likelihood ratio test (15.29, p-value=0.64) could not reject the null hypothesis these interaction effects are jointly zero. This suggests that there are no systematic

[9] In particular, firms located in less populated areas such as provinces in the north of the country, appeared less likely to be engaged in R&D collaboration.

[10] To test whether there are differential slope coefficients on past alliance variables between manufacturing and service firms we applied a Chow test (e.g., Gujarati, p. 513) by including 6 interaction effects in each equation between a service dummy and the past alliance strategies. The likelihood ratio test (15.29, p-value=0.64) could not reject the null hypothesis at any conventional level of significance that these interaction effects are jointly zero. This suggests that there are no systematic differences in the role of persistence and interrelation between the manufacturing and services industries in our sample.

differences in the role of persistence and interrelation between the manufacturing and services industries in our sample.

DISCUSSION AND CONCLUSIONS

This paper examined to what extent there is persistence in alliance engagement with different partner types (customers, suppliers, competitors) and to what degree alliance engagement with different partner types is interrelated. Empirical tests on a large panel set of innovating firms in the Netherlands provided support for the baseline hypothesis that alliances with individual partner types are persistent, that is: past engagement in alliances with a partner type predicts the propensity to be engaged in this type of alliance currently. While alliance engagement proves persistent for all three partner types, different types of alliances exhibit different degrees of persistence. Customer alliances are most persistent and significantly more so than supplier alliances. Whereas persistence of collaboration with suppliers may be attractive for the focal firm, the risk of spillovers and its corresponding remedial measures may reduce this propensity to some degree. In collaboration with customers though, this spillover risk may be outweighed by the strategic value of access to (scarce) information on specific customer needs and the higher likelihood of initial market acceptance and (future) commercial success, enhancing persistence of customer alliances.

Our study also demonstrated important interrelations between the three alliance types: prior engagement in alliances with one partner type affects the propensity to be engaged in alliances of another type. Here, our analysis confirmed an important interrelation between the two types of vertical alliances (collaboration with suppliers and customers). We found positive effects of past supplier collaboration on customer collaboration and vice versa. In addition, the strongest and

most significant persistence was found for joint supplier and customer alliance engagement. Such joint collaboration brings a focal firm in a better position for information exchange and resource (re)combination, while it also enhances opportunities for monitoring partner behavior and reputation building. This increases the likelihood that jointly developed capabilities and routines become more difficult to imitate and/or substitute, which contributes to the build-up of competitive advantage that is longer lived (Priem and Butler, 2001). This result is in line with earlier findings that firms persistently pursuing an integrative collaborative strategy across the value chain, with suppliers and customers, tend to exhibit superior performance (Narasimhan and Jayaram, 1998; Vickery et al., 2003; Frohlich and Westbrook, 2001; Rosenzweig et al., 2003).

Our study also revealed a very specific interrelation between horizontal and vertical alliance strategies. We observed a specific pattern that is in line with the idea of a 'punctuated equilibrium' strategy to combine exploration and exploitation through a temporal separation between the two activities (Burgelman, 2002; Levinthal and March, 1993; Gupta et al., 2006). Prior engagement in horizontal alliances consistently affected the propensity of engagement in supplier and/or customer alliance with a longer (4 years) lag, while no impact was found for effects with a shorter lag (2 years). This contrasted with strong effects of immediate past customer (supplier) alliances (t-2) on current supplier (customer) alliances. These findings are in line with our arguments that a longer lag allows for a sequence of discovery and experimentation in horizontal collaboration followed by upscaling and commercialization in vertical collaboration in such a way that governance risks can be mitigated while combinatory resource benefits can still be reaped. These considerations do not play a role in the case of interrelation between supplier and customer alliances. Here, a longer lag would cause a delay that inhibits the

alignment of collaboration with suppliers and customers that is required for accomplishing the strategic objectives of vertical collaboration.

In conclusion, our findings are highly supportive of the idea that alliance engagement with different partner types is interrelated. This is an interesting new insight that stands in contrast with the compartmentalized approach taken in most of the literature until now. Prior studies have often tended to focus on one type of alliances at a time or have implicitly considered horizontal alliances and vertical alliances as unrelated. Instead, our study shows that differences in partner attributes along partner types do matter and should not be ignored, as evident interdependencies operate across them.

We see our study contributing to the literature along several lines. First, while interdependencies between alliances engagement with different partner types have been studied in the portfolio approach to alliances (Vassolo et al, 2004; Wassner, 2009; Lokshin and Duysters, 2008), relationships between alliances with different partner types have not received due attention in prior studies. Our results may provide further reflection on the portfolio approach to alliances and inter-firm collaboration. Our analysis of joint customer-supplier technology alliances is informative of the process of alliance engagement resulting in the creation of alliance portfolios (how they come into being). Our findings may suggest that supplier collaboration or customer collaboration strategies are likely to be followed by an expansion of collaboration to include collaboration with the other vertical partner type, due to the synergistic effects between them. The process of alliance portfolio creation and the gradual evolvement of portfolios have been understudied and is an interesting avenue for future research (Hoffman, 2007; Wassmer, 2009). At the same time, our findings suggest that horizontal alliance strategies may be less likely to evolve into more differentiated alliance portfolio strategies. What our analysis suggests

is that while the portfolio approach examines simultaneous strategies, some particular alliance configurations may be more effective if combined in a more sequential manner, to reduce governance risks and to avoid conflict. This is partially related to the notion of sub-additivity or conflict in alliance portfolios (Vassolo et al, 2004; Wassmer, 2009) where combining certain types of alliances may lead to suboptimal results. Yet our study suggests that in some cases, alternating alliance strategies and an inter-temporal portfolio approach may solve such issues related to simultaneous alliance engagement. The understanding of the role of such interdependencies is important as they serve as critical determinants for the extent in which a firm derives value from its portfolio (Wassmer, 2009). Clearly, combining an inter-temporal and simultaneous dimension of alliance portfolios suggests a promising avenue for future research.

Our study also reflects on the network perspective on alliances. Whereas our findings are in line with the general wisdom that firms sharing strategic interdependence are more likely to engage in alliances when compared to non-interdependent firms (Gulati, 1995; Stuart, 1998; Gulati and Gargiulo, 1999; Hagedoorn, 2002), our study extends this commonly held idea in a number of ways. First, we go beyond the general notion of strategic interdependence by specifying its differences among partner types. Second, our finding that alliance engagement with different partner types is interrelated, indicates that persistence of alliance engagement with a specific partner type is not only shaped by bilateral dependence but also by interdependence with other partner types. Whereas until now collaboration has been considered as operating between firms from only two interdependent 'strategic groups' (Gulati, 1995), our findings suggest that alliance engagement is also affected by other strategic groups from which different partner types originate. Third, our study adds to a better understanding of how interrelationships between alliances types and time elapsed are related. Specifically, we found that the effect of past

engagement in horizontal alliances on current vertical collaboration only operated with a longer lag. Hence, a degree of delay can increase the propensity to be engaged in vertical collaboration rather than reduce it. This finding is consonant to the curvilinear effect of time elapsed on alliance formation found in pioneering work by Gulati (1995b). Whilst this effect was unexpected from a network embeddedness perspective in his study, the combination of a competence and governance perspective as taken in our study suggests that some delay enables to mitigate risks whereas too much delay sacrifices combinatory benefits.[11]

A final contribution relates to our approach to employ both a competence and governance view of strategic collaboration in order to shed more light on the extent to which risk profiles of different partner types interact with their resource complementarity. Here, we found that for persistence of vertical collaboration or horizontal collaboration the two perspectives are complementary as they suggest a similar effect on the propensity to be engaged in collaboration with vertical or horizontal partner types respectively. In contrast, when considering the interrelation between horizontal and vertical collaboration, we found that they form competing perspectives as they imply opposed effects on the propensity to be engaged in collaboration with another type. Hence, we contribute to the literature by demonstrating that the two perspectives can be both complementary and rival as far as strategic collaboration is concerned, depending on whether vertical and horizontal collaboration are considered apart or together.

Our research has a number of limitations, which should be addressed in future work. An important limitation was that the panel data set used does not identify alliance partners by name, such that we could not distinguish whether persistence is with the same or different firms within alliances types. The arguments that we proposed for same partner type persistence is broader and

[11] Interestingly enough, the optimum delay that he finds is approx. 3.8 years. This is very close to the four year lag that we found to be robust in our analysis.

relates to strategic collaboration needs and governance with a category of partners, within which firms may substitute a specific partner firm. A different research approach utilizing longitudinal datasets identifying partner names as well as partner types would allow examining differences in persistence across the same type and for the same partner. Another issue for future research relates to the 'reverse' positive effects found for past customer alliances (t-4) and recent past supplier alliances (t-2) on the propensity to be engaged in competitor alliances, which was not covered by our theory and hypotheses. An understanding of these effects would require first of all an understanding from how exploitation leads to exploration. This forms a largely unexplored issue in the literature until now as in most studies it has been considered how radical (technological) change impacts on established firms in an industry (Christensen, 1997; Tushman and Anderson, 1986; Tripsas, 1997), but leaves unexplained in how far such radical changes have their origins in current practices and technologies (Nooteboom, 2000). Although our empirical findings seem to indicate that such a relationship might be present, a more in-depth understanding of how exploration may potentially build on exploitation is required before we are able to predict how previous engagement in vertical collaboration increases the propensity to be engaged in horizontal collaboration.

Overall, our study provides new insights into the role and effects of dependencies across a firm's partner types, a largely overlooked issue in the literature until now (Lavie, 2007). This complements the network approach that, due to its focus on network structural properties, has ignored the role of partner attributes and the role of a differential propensity of engagement in collaboration with different partner types. Our study also complements the portfolio approach to alliances, by broadening the perspective to inter-temporal relationships between different alliances, and by examining relationships between three functional types of alliances. A

combined use of a competence and governance view has proven to be useful for a more profound understanding of the degree to which collaboration with different partner types is persistent, as well as in how far collaboration with different partner types is interrelated.

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TABLE 1 Variable definitions and descriptive statistics

Variable	Definition	Mean	SD
Dependent variables			
Customer alliance (*CUS*)	1 if the firm reported it was engaged in active R&D partnership with customers, else 0	0.10	0.30
Supplier alliance (*SUP*)	1 if the firm reported it was engaged in active R&D partnership with suppliers, else 0	0.13	0.34
Competitor alliance (*COM*)	1 if the firm reported it was engaged in active R&D partnership with competitors, else 0	0.07	0.25
Customer & supplier alliance (*CUS & SUP*)	1 if the firm reported it was engaged in active R&D partnership with customer and suppliers, else 0	0.08	0.27
Independent variable model Is			
Past customer alliance (t-2) (CUS_{t-2})	1 if the firm reported it was engaged in active R&D partnership with customers two years ago, else 0	0.10	0.30
Past customer alliance (t-4) (CUS_{t-4})	1 if the firm reported it was engaged in active R&D partnership with customers four years ago, else 0	0.09	0.29
Past supplier alliance (t-2) (SUP_{t-2})	1 if the firm reported it was engaged in active R&D partnership with suppliers two years ago, else 0	0.12	0.33
Past supplier alliance (t-4) (SUP_{t-4})	1 if the firm reported it was engaged in active R&D partnership with suppliers four years ago, else 0	0.11	0.31
Past competitor alliance (t-2) (COM_{t-2})	1 if the firm reported it was engaged in active R&D partnership with competitors two years ago, else 0	0.07	0.25
Past competitor alliance (t-4) (COM_{t-4})	1 if the firm reported it was engaged in active R&D partnership with competitors four years ago, else 0	0.07	0.25
R&D intensity (t-2) ($R\&D_{t-2}$)	R&D intensity; share of R&D employees in total employment	0.03	0.17
R&D intensity squared (t-2) ($R\&Dsq_{t-2}$)	R&D intensity; share of R&D employees in total employment squared	0.03	1.40
Firm size (t-2) ($SIZE_{t-2}$)	Logarithm of number of employees	4.81	1.04
Firm age	Firm age, in years	26.27	10.78
Part of a domestic group	1 if the firm is part of a domestic corporate group, else 0	0.51	0.49
Foreign multinational	1 if headquarters of the firm is located outside the Netherlands, else 0	0.34	0.47
Independent variables model II			
Past customer & supplier alliance (t-2) ($CUS\ \&\ SUP_{t-2}$)	1 if the firm reported it was engaged in active R&D partnership with customer and suppliers two years ago, else 0	0.07	0.25
Past customer & supplier alliance (t-4) ($CUS\ \&\ SUP_{t-4}$)	1 if the firm reported it was engaged in active R&D partnership with customer and suppliers four years ago, else 0	0.07	0.23
Past customer only alliance (t-2) (CUS_{t-2})	1 if the firm reported it was engaged in active R&D partnership with customers (but not suppliers) two years ago, else 0	0.03	0.16
Past customer only alliance (t-4) (CUS_{t-4})	1 if the firm reported it was engaged in active R&D partnership with customers (but not suppliers)four years ago, else 0	0.04	0.19
Past supplier only alliance (t-2)	1 if the firm reported it was engaged in active R&D	0.05	0.22

(SUP_{t-2})	partnership with suppliers (but not customers) two years ago, else 0		
Past supplier only alliance (t-4) (SUP_{t-4})	1 if the firm reported it was engaged in active R&D partnership with suppliers (but not customers) four years ago, else 0	0.05	0.21

TABLE 2a Correlation matrix among variables used in model I (N=4632)

	1	2	3	4	5	6	7	8	9	10	11	12	16	15
1 CUSt;	1.00													
2 SUPt	0.68	1.00												
3 COMt	0.56	0.53	1.00											
4 CUSt-2	0.20	0.19	0.12	1.00										
5 CUSt-4	0.15	0.15	0.13	0.16	1.00									
6 SUPt-2	0.22	0.23	0.15	0.59	0.14	1.00								
7 SUPt-4	0.11	0.12	0.10	0.15	0.51	0.17	1.00							
8 COMt-2	0.15	0.15	0.14	0.51	0.09	0.48	0.10	1.00						
9 COMt-4	0.10	0.11	0.10	0.09	0.40	0.07	0.38	0.14	1.00					
10 R&Dt-2	0.11	0.12	0.10	0.13	0.11	0.14	0.11	0.13	0.12	1.00				
11 R&Dsqt-2	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.06	0.06	0.87	1.00			
12 SIZEt-2	0.18	0.21	0.18	0.17	0.17	0.19	0.19	0.14	0.14	0.06	0.03	1.00		
13 MNEt	0.06	0.09	0.05	0.11	0.04	0.12	0.04	0.07	0.03	0.03	-0.01	0.09	1.00	
14 DOM GROUPt	0.03	0.04	0.03	0.01	0.02	0.02	0.02	0.00	0.01	0.00	0.02	0.03	-0.73	1.00
15 AGEt	-0.07	-0.05	-0.06	-0.03	-0.05	-0.02	-0.02	-0.02	-0.04	-0.05	-0.02	-0.05	-0.01	0.03

TABLE 2b Correlation matrix among variables used in model II (N=4632)

	1	2	3	4	5	6	7	8	9	10	11	12	16	15
1 CUS&SUPt;	1.00													
2 CUS_SUPt-2	0.20	1.00												
3 CUS_SUPt-4;	0.11	0.10	1.00											
4 CUS_Onlyt-2	0.04	-0.05	0.06	1.00										
5 CUS_Onlyt-4	0.10	0.04	-0.05	0.12	1.00									
6 SUP_Onlyt-2	0.09	-0.06	0.05	-0.04	0.06	1.00								
7 SUP_Onlyt-4	0.04	0.08	-0.06	0.03	-0.04	0.09	1.00							
8 COMt-2	0.15	0.53	0.07	0.11	0.05	0.10	0.07	1.00						
9 COMt-4	0.09	0.05	0.38	0.09	0.15	0.04	0.13	0.14	1.00					
10 R&Dt-2	0.10	0.13	0.10	0.04	0.04	0.04	0.04	0.13	0.12	1.00				
11 R&Dsqt-2	0.00	0.06	0.06	-0.00	-0.00	-0.00	0.00	0.06	0.06	0.87	1.00			
12 SIZEt-2	0.17	0.15	0.14	0.08	0.10	0.10	0.11	0.14	0.14	0.06	0.03	1.00		
13 MNEt	0.05	0.07	0.01	0.08	0.04	0.09	0.04	0.07	0.03	0.03	-0.01	0.09	1.00	
14 DOM GROUPt	0.03	0.01	0.00	0.03	0.02	0.04	0.02	0.00	0.01	0.00	0.02	0.03	-0.73	1.00
15 AGEt	-0.05	-0.02	-0.03	-0.03	-0.04	-0.00	0.01	-0.02	-0.04	-0.05	-0.02	-0.05	-0.01	0.03

TABLE 3

Multivariate probit analysis of the propensity to form technology alliances

	Customer alliance	Supplier Alliance	Competitor alliance
	(1)	(2)	(3)
CUS_{t-2} (Customer alliance in t-2)	0.34*** (0.07)	0.13† (0.08)	-0.02 (0.14)
CUS_{t-4} (Customer alliance in t-4)	0.50*** (0.11)	0.39*** (0.11)	0.41** (0.14)
SUP_{t-2} (Supplier alliance in t-2)	0.24*** (0.08)	0.33*** (0.07)	0.16† (0.08)
SUP_{t-4} (Supplier alliance in t-4)	-0.06 (0.08)	0.01 (0.11)	0.00 (0.08)
COM_{t-2} (Competitor alliance in t-2)	0.08 (0.12)	0.09 (0.08)	0.30** (0.12)
COM_{t-4} (Competitor alliance in t-4)	0.21* (0.10)	0.24** (0.07)	0.15† (0.09)
$R\&D_{t-2}$ (R&D intensity in t-2)	3.41*** (0.68)	3.11** (0.66)	3.14*** (0.46)
$R\&Dsq_{t-2}$ (R&D intensity squared in t-2)	-1.67** (0.65)	-1.51* (0.64)	-1.48*** (0.51)
$SIZE_{t-2}$ (Firm size in t-2)	0.21*** (0.03)	0.23*** (0.03)	0.23*** (0.03)
AGE_t (Firm age in t)	-0.01* (0.00)	-0.01* (0.00)	-0.01* (0.00)
MNE_t (MNE in t)	0.25** (0.08)	0.27*** (0.10)	0.17* (0.09)
$DOM\ GROUP_t$ (part of domestic group in t)	0.15* (0.06)	0.15 (0.09)	0.06 (0.08)
Constant	-3.76*** (0.21)	-3.17*** (0.24)	-3.41*** (0.19)
Rho/2	0.88*** (0.02)		
Rho/3	0.81*** (0.03)	0.79*** (0.03)	
Time dummies	Included	Included	Included
Industry dummies	Included	Included	Included
Location (province) dummies	Included	Included	Included
Number of firms	3181	3181	3181
Number of observations	4632	4632	4632
Wald $\chi^2(39)$, p-value< 0.001	671.49		
Log-likelihood	-2581.53		

Notes: Robust standard errors in parentheses
† p<0.1 (Significant at 10% level)
* p<0.05 (Significant at 5% level)
** p< 0.01 (Significant at 1% level)
*** p< 0.001 (Significant at 0.1% level)

TABLE 4

Probit analysis of the propensity to form customer & supplier technology alliances

	Customer & Supplier Alliance
Past alliance with:	
CUS_SUP$_{t-2}$ (Customer & supplier alliances in t-2)	0.67*** (0.11)
CUS_SUP$_{t-4}$ (Customer & supplier alliances in t-4)	0.41** (0.14)
CUS_Only$_{t-2}$ (Customer alliance only in t-2)	0.47** (0.18)
CUS_Only$_{t-4}$ (Customer alliance only in t-4)	0.60*** (0.16)
SUP_Only$_{t-2}$ (Supplier alliance only in t-2)	0.34** (0.13)
SUP_Only$_{t-4}$ (Supplier alliance only in t-4)	0.03 (0.13)
COM$_{t-2}$ (Competitor alliance in t-2)	0.12 (0.11)
COM$_{t-4}$ (Competitor alliance in t-4)	0.23* (0.09)
R&D$_{t-2}$ (R&D intensity in t-2)	2.29*** (0.57)
R&Dsq$_{t-2}$ (R&D intensity squared in t-2)	-1.00* (0.49)
SIZE$_{t-2}$ (Firm size in t-2)	0.21*** (0.03)
AGE$_t$ (Firm age in t)	-0.01† (0.00)
MNE$_t$ (MNE in t)	0.13 (0.09)
DOM GROUP$_t$ (part of domestic group in t)	0.11 (0.07)
Constant	-4.65*** (0.30)
Time dummies	Included
Industry dummies	Included
Location (province) dummies‡	Included
Number of firms	3181
Number of observations	4632
Wald $\chi^2(41)$, p-value< 0.001	752.44
Log-likelihood	-935.50

Notes: Robust standard errors in parentheses
† p<0.1 (Significant at 10% level)
* p<0.05 (Significant at 5% level)
** p< 0.01 (Significant at 1% level)
*** p< 0.001 (Significant at 0.1% level)

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