# Why are some coalitions more successful than others in setting standards? Empirical evidence from the Blu-ray vs. HD-DVD standard war

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Document de Travail
n°2010-53



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December 2010

# Why are some coalitions more successful than others in setting standards? Empirical evidence from the Blu-ray vs. HD-DVD standard war[1]

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*November 15 2010*

## Abstract

Standard-setting coalitions are increasingly composed of rival firms from different sectors and are characterized by simultaneous and/or sequential cooperation and competition among their members. This paper examines why firms choose to belong to two standard-setting coalitions instead of one and what determines the success of a standard coalition. We test empirically for network effect, experience effect, and coopetitive effect in the Blu-ray vs. HD-DVD standard war. We find that the higher the similarity of the members in the coalition, the greater the probability of standard coalition success. Furthermore, relatedness leads to a greater probability of joining both competing coalitions, but at a given degree of knowledge difference, an opposite effect exists.

**Keywords:** Blu-ray, HD-DVD, coalition, coopetition, standard war

[1] Financial support from the French program ANR-08-RISKNAT ("Riskemotion" grant number 007-01) is gratefully acknowledged. We thank participants to the Fourth EIASM workshop on coopetition strategy (Montpellier, June 2010) and Marjorie Sweetko for helpful suggestions. Corresponding author: Zouhaïer M'Chirgui: Zouhaier.MChirgui@euromed-management.com.

## 1. Introduction

The last two decades have seen a marked increase in standardization (Arthur, 1998; Warner, 2003), especially with the convergence of the various technologies and demand from information technology, media and telecommunications and the resulting broader portfolio of competencies. This has led to an increased need for standards for the rapidly growing industries involved in the delivery both of data and content and of digitalization (Shapiro, 2001a).

In this respect, both competitors and complementary component providers have incentives to work together to develop, establish, endorse and promote common standards. This should provide many opportunities for cooperation aimed at offering adequate support to ensure the success of new technologies and standards.

Several examples show the need for cooperation to successfully establish new standards: in the consumer electronics sector (Gandal et al., 2000; the Sony/Philips standards for CD players and disks, Cusumano et al., 1992; Ohashi, 2003; the VHS standard for video cassette players; Dranove and Gandal, 2003; digital versatile disks; Egyedi & Koppenhol, 2009; document formats ODF and OOXML), in the computer hardware sector (Koski, 1999; personal computers), in the computer software sector (Brynjolfsson and Kemerer, 1996), in the financial sector (Miller and Rao, 1994; Shapiro and Varian, 1999 for ATM) in the communications sectors (Augereau and Greenstein, 2001; 56K modems; Korzeniowski, 1999; FDDI) and in wireless telecommunications (Leiponen, 2008; UMTS).

Thus, it is not unusual to find companies like Sony, JVC, Hitachi, Matsushita (Panasonic) and Toshiba, or Sun Microsystems and Microsoft closely linked through a series of relationships that are both cooperative and competitive, known as "coopetition" (Nalebuff and Brandenburger, 1996; Bengtsson and Kock, 2000). For example, from 2001 to 2005, IBM, Sony and Toshiba teamed up to develop high-performance microprocessor (called Cell). In 2004, Hitachi, Toshiba and Matsushita agreed to jointly establish a company to manufacture liquid crystal display (LCD) panels for flat-panel TVs. Meanwhile, Sony and Toshiba were fighting in the Blu-ray versus HD-DVD standards war and Sun Microsystems and Microsoft in the document format standard war.[2]

In fact, cooperative agreements among competitors have proliferated in recent years (Padula and Dagnino, 2007; Ghosh and Morita, 2007) and about 50 percent of new alliances are among competitors, according to Harbison and Pekar (1998) or Gnyawali and Madhavan (2001). Although standardization may lead to voluntary cooperation among players concerned with obtaining a standard that will meet consumer interests, ensuring the competitiveness of the firms or interoperability, standardization processes are also the result of standard wars (Shapiro and Varian, 1999). It is thus not unusual to find apparently contradictory interests driving the standardization processes. Standardization is therefore the result both of voluntary cooperation among some of the parties and of intense competition among them.

Coalitions formed in support of a particular standard increasingly rely on heterogeneous actors from different sectors forming a community based on strategic interest or value networked around a founder-leader capable of imposing or communicating its marketing

[2] ODF supported by Sun Microsystems and OOXML supported by Microsoft.

approach or technological standard. These coalitions involve rivals firms ranging from manufacturers, innovation specialists, integrated firms to distributors and commercial companies. Mixed coalitions of rival firms from different business sectors constitute business ecosystems (Moore, 1996; Iansiti and Levien, 2004). These business ecosystems are characterized by simultaneous and/or sequential cooperation and competition among their members. The underlying objective of these alliances of competitors (alliances which form specific coalitions) is to avoid a greater threat - that other business ecosystems might emerge - and to obtain a cost advantage through economies of scale (Barney, 2002).

However, even when a coalition's standard succeeds without major obstacles (Schmalensee, 2009), we do not yet fully understand the factor determining either a coalition's success or the choice of a coalition by its members. The literature on standardization generally takes two directions: one focusing on the economic basis of the standards (Arthur, 1994; Shapiro and Varian, 1999; Suarez, 2004) and the other on the process of standard setting (Greenstein, 1992; Weiss, 1993; Lyytinen and King, 2006). Few papers have examined the role of coalitions in the success of standards and why some coalitions are more successful than others in standard setting, either theoretically (Axelrod et al., 1995; Foray, 1995; Lukach et al., 2007) or empirically (for example Chiesa et al., 2002 for the multimedia sector; Funk, 2009 for the mobile phone industry; Leiponen, 2008 for wireless telecommunications; Cortese et al., 2009 for the IFRS standard in mining industries).

The Blu-ray vs. HD-DVD standard war started in 2004. Unlike the VHS/Betamax war, Sony and Toshiba's strategies were almost identical. Both firms tried to attract various types of partners to their own solution in order to create business ecosystems with the common interest of respectively imposing Blu-ray or HD-DVD as the market standard. The Blu Ray Disc Association aimed to promote Blu-ray whereas the HD-DVD Promotional Group (Japan), the European HD-DVD Promotional Group and the North American HD-DVD Promotional Group were formed to promote this standard in the relevant countries. Various industrial firms promoted the two formats by joining one or even both coalitions. Stakeholders and distribution networks chose to favor one particular coalition: for example, Wal Mart and Best Buy distribution channels chose to withdraw films on HD-DVD and sell only Blu-ray films. The standard war ended in February 2008 with the victory of the Blu-ray coalition.

Against this background, we focus here on factors that influence standard-setting coalition success and the decision to join one or both coalitions. We test empirically for network effect, experience effect and coopetitive effect in the Blu-ray vs. HD-DVD standards war by considering how (1) the size of participants (2) prior alliances and (3) the number of direct competitors involved within the standard-setting coalition affect the success of the standard.

Our data cover 261 companies with 125 supporting the Blu-ray Disc coalition only, 70 companies supporting the HD-DVD coalition only and the remaining 66 companies supporting both standards. Five groups of firms supporting each coalition were distinguished: format founders & competitors,[3] movie studio supports, major movie rental outlets, nationwide retail & major online supports, and miscellaneous companies (companies listed as Members, Associate Members, or Contributors).

The aim of this study is to contribute to the understanding of the processes and effects of coopetitive standard setting. Although the presence and magnitude of network effects have

[3] Including companies listed as Members of the Board or Managing Members and notably grouping two categories of players: electronic goods manufacturers and ITC firms.

been empirically demonstrated in the literature (Park, 2004), to the best of our knowledge there has been no empirical work on the Blu-ray versus HD-DVD standard-setting coalitions nor on the associated interaction between network effects, coopetitive effect and social network effect.Our results add to the literature both on technology strategy and on policy. Management implications suggest that a broad coopetitive standardization approach is more beneficial than focusing on a few cooperative arrangements.

This paper is organized as follows. Section 2 describes the empirical context and reviews the existing literature to derive empirical hypotheses. Section 3 presents the methodology and data. Section 4 details the results and Section 5 discusses and concludes.

## 2. Theory and hypotheses

The video storage format industry provides promising material on standards in the consumer electronics markets. While the VHS vs. Betamax standards war for video cassette players has been the focus of much attention (Cusumano et al., 1992; Ohashi, 2003), this paper focuses on the recent standard war between Blu-ray and HD-DVD, respectively originated by Sony and Toshiba. The two companies were involved in mixed games of cooperation and competition throughout the two standards wars. For instance, in the VHS/Betamax war they were allies against the JVC - Matsushita (Panasonic) coalition and were the losers; however in the most recent war they were direct competitors.

The advantages of standardization are well known: low integration costs, easy market entry, faster product innovation and availability and greater return on investment (see for example Suarez, 2004). Numerous attempts have been made to identify the determinants of standard-setting success. The most often mentioned determinants are size (Weiss and Sirbu, 1990; Axelrod et al., 1995) and network effect (Katz and Shapiro 1986; Farrell and Saloner, 1985). However, network construction (Gulati, 1995; 1998) and coopetitive effect (Bengtsson et al., 2010) have seldom been researched.

### 2.1 Network construction

***Prior ties between partner firms (experience)***

Strategic alliances represent appropriate means for building and locking-in a market, which evolve into alliance blocks or alliance constellations (Gomes-Casseres, 1996; 2003). Alliance block membership as an alliance network significantly influences performance (Duysters and Lemmens, 2008) and can be an efficient way of determining the emergence of new standards, new concepts and new operating modes in industries (Cowan and Jonard, 2009).

As a result, standard wars regularly turn into wars between coalitions (Vanhaverbeke and Noorderhaven, 2001). These coalitions unite various companies that all have a common interest in the standard's victory: companies developing the standard, firms developing complementary goods or services, or belonging to a distributor network. Coalitions or alliance blocks are, then, heterogeneous: they come from different sectors supporting horizontal, vertical and transverse relationships in a dynamic perspective (Hearn and Peace, 2006).

Although several studies have examined the effects of relational and structural embeddedness on company and alliance performance (see e.g., Gulati and Gargiulo, 1999; Rowley et al. 2000; Gnyawali and Madhavan, 2001), this study focuses on external networks of cooperation (Leiponen, 2008). Prior alliances or experience offer partners the opportunity to learn from and about each other (Inkpen, 1998), along with more expertise, information, knowledge and capabilities (Gulati, 1998). From the resource-based viewpoint (Barney, 1991; Wernerfelt, 1984), past experience represents a way to accumulate internal knowledge and develop specific competencies. Prior participation in previous external coalitions enables firms to bring to the current coalition their expertise, experience and technologies in more efficient ways. Klepper and Simons (2000) show that prior experience and reputation in radio production gave firms an advantage over new entrants in the emerging TV industry. Further, in the game console industry the successful introduction of Sony's Playstation 1 in 1995 despite Nintendo's leadership position was strongly and significantly due to its reputation and credibility as highlighted by Gallagher and Park (2002). This enabled the coalition to successfully impose its standard and gain the advantage. Moreover, since coalitions are difficult to manage when partners have divergent interests, managing alliances requires specific competencies. These can be developed through repeated experience of alliance forming and management (Sampson, 2005; Moatti, 2009). Therefore, we expect alliance experience to positively affect the success of a coalition's standard.

*HYPOTHESIS 1a. The greater the number of prior alliances and participation in external consortia, the greater the success of a coalition's standard.*

***Prior ties among competitors* (*social distance*)**

Moreover, although prior ties provide companies with more expertise, information, knowledge and capabilities, prior experience **with coalition membership** provides more trust and willingness to share knowledge (Tsai and Ghoshal, 1998; Levin and Cross, 2004; Singh, 2005). Thus, knowledge is more likely to be easily exchanged and transmitted, which may improve the coalition's ability to influence standard setting. Prior ties among a coalition's members increases the efficiency of technical teams, at negotiations level and consequently in standard development (Leiponen, 2008). Prior collaboration with members of the coalition and especially with direct competitors could convey the degree of social distance (Singh, 2005; Xia et al., 2008). Therefore, from this social network perspective, we argue that prior experience influences subsequent standardization decisions.

*HYPOTHESIS 1b: The greater the number of prior alliances among competitors, the greater the success of a coalition's standard.*

## 2.2 Size and network effect

One striking phenomenon associated with standardization is network effects. Network effects arise when there is inter-dependence among different components or members of an economic system (Hirschman, 1958). An example of a market characterized by virtual network effects is the consumer electronics market (Gandal and Shy, 2001): the utility of consumers is increasing through the variety of complementary products available for a base product. Network effects may also be driven by large platform leaders (Simcoe, 2008) who coordinate different types of members. This leads to a dominant platform, although major or dominant firms are not required for a dominant platform (Bresnahan and Greenstein, 1999).

Generally speaking, it is now widely recognized that increasing returns (Arthur, 1994, 1998), network effects (Katz and Shapiro 1986) and installed base, i.e. the number of units actually in use, (Farrell and Saloner, 1985) are key drivers of standard wars. Both theoretical and empirical evidence suggest that in many markets with standard competition, network effects help the strong become stronger and can “tip” the market toward a single, winner-take-all standard (Liu et al., 2008). As Shapiro and Varian (1999) say: “*Standards wars are especially bitter in markets with strong network effects, where consumers place great value on compatibility and interconnection with each other. These markets tend to exhibit positive feedback and "tip" to a single winner*”.

Numerous empirical works have emphasized the role played by these variables in different markets such as video cassette recorders (Cusumano et al., 1992), automated teller machines (Saloner and Shepard, 1995); U.S. telecommunications (Majumdar and Venkataraman, 1998), compact disks (Gandal et al., 2000), DVD (Dranove and Gandal, 2003), 56K modems (Augereau and Greenstein, 2001) or flash memory cards (Liu et al., 2008). One of the arguments put forward by these studies is that the standard’s value increases when network size reaches critical mass. In other words, the size of the installed base provides an “extra push” to the chances of a standard’s success.

In addition, alliance or coalition size is a determinant factor in a firm’s decision to join a coalition (Weiss and Sirbu, 1990). Firms decide to join the largest coalition to increase the likelihood of success (Axelrod et al, 1995; Weiss and Cargill, 1992). Several studies have shown that network effects (Dranove and Gandal, 2003) and the number of firms in a coalition (Valdes-Llaneza and Garcia-Canal, 2006; Leiponen, 2008; Aggarwal, Dai and Walden, 2009; Waguespack and Fleming, 2009) play a significant role in reducing market risk and consequently affect the standard’s success.

*HYPOTHESIS 2a. There is a positive relationship between the size of the firms involved in the coalition and the success of a standard.*

In a similar vein, the size of the firms in the coalition determines their contribution in power and reputation, and consequently can affect the rate of R&D collaboration (Hypothesis 2b). There are some indications in the literature that larger companies have a higher propensity to engage in partnerships than smaller companies (Duysters and Hagedoorn 1995; Mytelka 1991), which could explain their participation in coalitions (Duysters and Lemmens 2008). Therefore, we expect the size of coalition members to determine whether they are key-players. In such cases the absolute as well as the relative size of the coalition is important (Backhaus et al., 2009) and the size of the coalition is more important in earlier years than in later years with respect to levels of technology adoption (Majumdar and Venkataraman, 1998).

*HYPOTHESIS 2b. There is a positive relationship between the size of R&D expenditure across the firms in the coalition and the success of a standard.*

Knowledge of intellectual property rights (IPRs) - including patents, copyrights, and trademarks that may directly impact the standard-setting process (Shapiro, 2001b) - is imperative for establishing any industry technology standard that effectively facilitates widespread commercialization of innovations. Further, patents are increasingly involved in various competition policies related to standard-setting organizations (Schmalensee, 2009). Standards in the information and communications technology sectors often involve complex technologies and consequently require the use of multiple patented technologies. Digital technology, for example, lowers the cost of reproduction and enables new forms of transmission. This poses threats to copyright industries and market structures that have evolved on the basis of older technologies and definitions of property rights linked to these older technologies. "*Companies therefore optimally patent all innovations, and patents become an exact measure of innovative activity*" (Horstmann et al., 1985, p. 838). Therefore, we argue that the coalition which has the largest patent portfolios is the most likely to achieve higher technological innovation standards, which may contribute to its success.

*HYPOTHESIS 2c. There is a positive relationship between the coalition's stock of technology (technology dominance) and the success of a standard.*

### 2.3 Coopetitive effects *(Direct competitors & Relatedness)*

Establishing strategic alliances with rivals is perfectly in line with the logic of "coopetitive" strategies in business ecosystems (Dagnino and Padula, 2002; Le Roy and Yami, 2009). Coopetition occurs when rivals both cooperate and compete according to simultaneous and/or sequential multi-dimensional sequences. Standardization is a relevant example of how the coopetition has evolved (M'Chirgui, 2005). One striking feature of recent decades is the proliferation of rivals grouping in a single coalition, also known as platform leaders (Gawer and Cusumano, 2008). Rival firms in various sectors group together within business ecosystems (Moore, 1996) to impose a standard against the standards backed by rival business ecosystems. They cooperate within the business ecosystem and compete for the position of leader(s) within the same business ecosystem and on the markets with products incorporating the standard.

When battling to be the winner in a standard war, companies should try to gain control over an installed base, broadly license their intellectual property and facilitate partner investment in complementary innovation (Shapiro and Varian, 1998). They should also invest in building brand equity as well as manufacturing, distribution and service capabilities (Gawer and Cusumano, 2008). Thus, the dimensions of coopetitive games affect both vertical and horizontal relationships relying on suppliers, complementors, competitors, distributors, etc. This seems particularly important in the context of technological convergence, which is pervasive in sector like computers, telecommunications equipment and digital appliances.

Well-known examples of this logic are the famous JVC's VHS versus Sony's Betamax for videocassette recording and Microsoft's Windows versus Apple's Macintosh for personal computer operating systems. The standard war between Sony's Blu-ray and Toshiba's HD-DVD for high-definition media storage also exemplifies such behavior. Therefore the presence of a sufficient number of major rivals from different sectors broadens the installed base and consequently increases the standard's chances of success.

However, because we are dealing with two standards only in this paper, the number of competitors cannot be directly used in the model to test for a coopetitive effect: such a number would be a perfect predictor of success. We circumvent this by considering knowledge-relatedness or technical distance as an indicator of the presence of rivals within a coalition. Technical distance is the degree of dissimilarity in technology knowledge bases between two firms. A large technical distance is known to be more likely to impede the achieving of synergies in alliances (Bleeke and Ernst, 1995; Yang and Lin, 2005) and to have a negative effect on absorptive capacity (Cohen and Levinthal, 1990). A standard coalition is basically technology-driven and run by multiple alliance business market groups. If there is a big gap in knowledge-relatedness among groups of companies within the coalition, conflict can arise and interests increasingly diverge. Differences in performance among competing coalitions can be attributed to the nature of the technological knowledge they possess and their ability to exploit that knowledge (Steensma and Corley, 2000). Unrelated technologies often require a radical change in the way research is organized (Kogut and Zander, 1992) and consequently become counterproductive (Dosi, 1988). Thus, too great a cognitive distance makes basic mutual understanding unachievable (Gilsing and Duysters, 2008).

However, the opposite may in some cases be true. A coalition composed of different business market actors, each forming alliance groups, will more easily overcome any lack of competencies or technologies, especially when the founders have made a preliminary selection. Yet, as a standard coalition aims to bring together different innovation partners, external knowledge is crucial because any innovation arises from the recombination of component elements (Kogut and Zander, 1992). Difference in knowledge is therefore important for learning and innovation (Nelson and Winter, 1982). In addition, the presence of several major complement producers from different industries increases the likelihood of reaching critical mass quickly through network effects and group technological specialization (Duysters and Lemmens, 2008). Therefore groups with higher technological specialization are likely to be more innovative, making them particularly attractive team members. The groups' knowledge-relatedness therefore seems to have an effect on the success of a standard coalition. In this paper we argue that high knowledge-relatedness negatively affects the likelihood of a coalition's success.

*HYPOTHESIS 3. High knowledge-relatedness decreases the likelihood of success of a standard-setting coalition*

Some degree of differentiation in technological capabilities among the companies may enrich the coalition knowledge base and create opportunities for learning (Hitt et al., 1996) provided that it is moderate. Several studies have stressed the importance of cooperation among companies with a minimum degree of similarity in their knowledge-base in order to maintain sufficient absorptive capacity (Stuart, 1998; Tanriverdi and Venkatraman, 2005; Goerzen and Beamish, 2005). Others have even split this degree of difference into multiple dimensions, arguing the curvilinear effect of cognitive distance on innovation (inverted U-shaped) (Nooteboom, 1999; Nooteboom et al., 2007). Thus, an inter-industry difference between the innovating company and its partners can be interpreted as one of the specific dimensions of cognitive distance (Li and Vanhaverbeke, 2009).

## 3. Methodology

### 3.1 Sample and data

The sample consists of the agreements undertaken by founders Sony (for Blu-ray) and Toshiba (for HD-DVD) to form their standard coalition. Data were directly collected from internet sites and several databases. Two types of site were consulted, namely corporate coalition member sites and sites specializing in the fields of ITC, video and mass-produced electronic goods. The search criteria used were alliances, coalitions and other forms of cooperation among business ecosystem members.
Such a method based on secondary data raises certain issues. First, the reliability of secondary data, particularly when it comes from websites, may be difficult to establish (Dochartaigh, 2002). To ensure data was as reliable as possible, we crosschecked various information sources (in particular comparing information found on corporate websites with that found on specialized sites) and systematically rejected insufficiently reliable information. Further, information was crosschecked from Securities Data Corporation (SDC), which offers data on

alliance activity starting from 1984 (Schilling, 2009). Secondly, standard sponsors' and co-sponsors' corporate websites are used to disseminate information as well as for communications between these players. To limit the risk of propaganda inherent in these players' official communications, great care was devoted to checking the reliability of these sources by comparing them with non-corporate websites.

Coalitions give rise to bipartite networks (Borgatti and Everett, 1997, Newman et al., 2002) that have two types of nodes, in our case individual member companies and standard coalition founders. Companies can only connect to founders, not directly to other companies of the same coalition, which reduces the number of links formed within a coalition. However, indirect links are not excluded. The bipartite network thus gives rise to a unipartite projection where companies are connected with each other if they are co-members (Newman et al., 2002). In the bipartite network, a firm's degree is the number of memberships, while a coalition's degree is the number of members. In the projected unipartite network, a firm's degree is the sum of members (excluding the focal firm) in the coalition in which it participates. The existing literature is still unclear on the differences between bipartite structure and unipartite projection and usually only the latter is examined. However, because it is relevant to consider bipartite structure for networks with affiliation characteristics (Leiponen, 2008), we chose it to study standard-setting success.

The total sample consisted of 261 member companies, 191 belonging to the Blu-ray coalition, 136 belonging to the HD-DVD coalition, and 66 belonging to both coalitions. The data came from SDC's Alliance Database for network construction variables, Compustat for information on companies, and Delphion for patents. The data cover the 2000-2008 period, which is appropriate, as the standard war started around 2004 and ended in February 2008.

### 3.2 Variables

Table 1 provides an overview of the way each variable is constructed along with the expected signs based on the hypotheses above and the data source, and each variable is detailed below (see also Appendix 1 for descriptive statistics).

***Dependent variables.*** The first dependent variable deals with the decision to choose to belong either to one coalition or to both coalitions. It is referred to as **COALITION**. This variable is coded 1 if the company chooses to join both coalitions and 0 if the company chooses to belong to either the HD-DVD or the Blu-Ray coalitions.
The second dependent variable measures the companies' ability to affect the standard's success. It is referred to as **SUCCESS**. A focus on the bipartite network is appropriate because Blu-ray vs. HD-DVD coalitions are characterized by group structures or alliance blocks. The dependent variable is a binary choice variable that takes the value 1 if the company belongs to the winning coalition (i.e. Blu-ray) and 0 otherwise.

***Explanatory variables***. Some hypothesized effects need to be measured by social network analysis. The first variable, called **EXPERIENCE**, is the number of prior alliances concluded by each member of the coalition. As explained in the lead-up to Hypothesis 1, these prior ties indicate the level of expertise, information, knowledge and capabilities developed and held by companies over the past. It indicates the experience of membership of each coalition. Hypothesis 1a suggests that a large number of prior alliances by the companies in the coalition increases the probability of success compared to coalitions with a smaller number of prior alliances. Therefore, we expect a positive sign for this variable.

The second variable, called **SOCIALDistance**, measures the number of prior alliances with competitors belonging to the same coalition. These prior ties are indicators of how well the coalition members know each other and the extent to which information asymmetry and indigestibility problems (Hennart and Reddy, 1997) can be assumed to be mitigated. Thus, it indicates the degree of social distance (Singh, 2005), which is essential for the efficiency of technical teams and consequently the standard outcome (Leiponen, 2008). We expect a positive coefficient according to Hypothesis 1b. The prior alliance data for both variables are obtained from the SDC's Alliances database.

**Table 1: Description of variables and expected sign**

| **Variables** | **Measure** | | | |
|---|---|---|---|---|
| **Dependent variables** | | | | |
| COALITION | The company belongs to both coalitions (=1), 0 otherwise | | | |
| SUCCESS | The company belongs to the winning coalition (=1), 0 otherwise | | | |
| **Explanatory and control variables** | | **Hypothesis** | **Sign** | **Source** |
| ***Network construction*** | | | | |
| EXPERIENCE | Number of prior alliances concluded by each member of the coalition. | H1a | + | SDC |
| SOCIALDistance | Number of prior alliances with competitors belonging to the same alliance. | H1b | + | SDC |
| ***Size and Network effect*** | | | | |
| EMPLOYEES | Number of employees of a partner (every year from 2000 to 2008). | H2a | + | Compustat |
| REVENUE | Revenue of a partner (every year from 2000 to 2008). | H2a | + | Compustat |
| R&D expenditure | Total R&D expenditure of a partner (every year from 2000 to 2008). | H2b | + | Compustat |
| PATENT | Number of patents held by members of coalition during the period 2000-2008, indicating technology dominance. | H2c | + | Delphion, USPTO, EPO |
| ***Coopetitive effect*** | | | | |
| RELATEDNESS | Average measure of the distance in the SIC codes of coalition partners. | H3 | - | Compustat |

The variables **REVENUE**, number of **EMPLOYEES** and **R&D expenditure** are used as proxies for firm size. Information is available for publicly traded companies and our sample is mainly composed of these companies. These data were collected from Compustat on yearly basis from 2000 to 2008. We also compute the percentage change in the Revenue variable from 2000 to 2008 (variable **PERCREV**) and the percentage change in the R&D expenditures variable from 2000 to 2008 (variable **PERCR&D**), which are proxies of the dynamism of a partner.[4] According to Hypotheses 2a and 2b, we expect the coefficients of these variables to be positive.

[4] Because a decrease in the number of employees can result from improved efficiency or investment in technology, we did not compute the percentage change in the number of employees. Monck et al. (1988) and Löfsten and Lindelöf (2002) found, for instance, that performance in terms of employment size depends upon the age of the firm and show that there is no significant difference between their performances in terms of employment.

Coalition technological capabilities involve intellectual property. Therefore we use patents (**PATENT**) to indicate the innovative capabilities and technological dominance of each coalition. We used two databases: the Delphion and the USPTO (United States Patent and Trademark Office). The Delphion database collects yearly patent counts for each of the firms, aggregating subsidiary patents up to the ultimate parent level (variable **PATENT_Delphion**). Patents granted were counted in their year of application. Yearly patent counts were created for each company for the period from 2000 to 2008. As Delphion gathers patents from different worldwide patent offices and to avoid patent duplication, we crosschecked patents from USPTO, Japanese patent offices and European patent offices (variable **PATENT_USPTO**). According to Hypothesis 2c, the coefficients of these variables are expected to be positive.

Finally, the variable **RELATEDNESS** measures the distance in the SIC codes of coalition members. It is a proxy for coopetitive relationship as well as information asymmetry, assessing dissimilarities in the parties' SIC codes (Villalonga and McGahan, 2005). The computation of the distance/proximity between two SIC codes may differ across authors and we choose the method used by Li and Vanhaverbeke (2009). A difference between two members of a coalition in the SIC's first digit indicates that these two companies have the largest possible difference, whereas two members of a coalition with the same first four digits SIC-code are assumed to have a common knowledgebase. The largest difference is measured by 4, and identical industries are measured by 0. To be more precise, the dyadic relatedness is 0 if the primary SIC codes of the partners have the same first four digits, it is 1 if they have the same first three digits, it is 2 if they have the same first two digits, it is 3 if they have the same first digit and it is 4 if the first digit differs. We then compute the average Relatedness of each member with respect to all other members belonging to the same coalition. According to Hypothesis 3 we expect the coefficient of the variable to be negative.

**Control variables**. Because there are some variables not considered in the hypotheses that may influence coalition success, we controlled for the two following variables (see Table 2 for their distribution in the sample).
*The nationality of the partner*: We use dummy variables to distinguish between Asian partners (**ASIA**), North-American partners (**NORTH-AMERICA**) and European partners (**EUROPE**).
*The status of the partner*. We distinguish 5 groups of partners supporting a coalition: format founders and competitors (**FORMATFOUNDER**)[5], movie studio supports (**MOVIE**), major movie rental outlets (**MAJOR**), nationwide retail and major online supports (**ONLINE)**, and companies listed as Members, Associate Members, or Contributors (**MISCELLANEOUS**).

[5] Including companies listed as Members of the Board or Managing Members.

**Table 2 Distribution of the status and the nationality of the partners by coalition (n=261)**

| | HD-DVD | Blu-ray | Both coalitions | Total |
|---|---|---|---|---|
| **Status of the partner** | | | | |
| **Format founder** and competitors | 2 | 13 | 9 | **24** |
| **Movie** Studio supports | 3 | 12 | 0 | **15** |
| **Major** movie rental outlets | 0 | 2 | 1 | **3** |
| Nationwide retail and major **Online** supports | 0 | 2 | 5 | **7** |
| **Miscellaneous** (Members, assoc. members and contributors) | 65 | 96 | 51 | **212** |
| **Total** | **70** | **125** | **66** | **261** |
| **Nationality of the partner** | | | | |
| **Asia** | 25 | 44 | 38 | **107** |
| **Europe** | 6 | 20 | 5 | **31** |
| **North-America** | 13 | 40 | 13 | **66** |
| **Missing** | 26 | 21 | 10 | **57** |
| **Total** | **70** | **125** | **66** | **261** |

It can be seen that no Major movie rental outlets or nationwide retail and major Online supports belong to the HD-DVD coalition, whereas no Movie studio support belong to both coalitions. The nationality was known for 79.2% of the partners. The majority were from Asian countries (52.4% including Australia and New-Zealand), almost one third were from North-American countries (32.4%) and the remainder from European countries (15.2%, including Israel).

Although the number of partners cannot be used in the models, it is obvious that the Blu-ray coalition contains the largest overall number of partners as well as the largest internal groups of partners, especially with respect to Format Founders (horizontal coopetition) and Movie Studio, Major movie rental and Online supports (vertical coopetition).

### 3.3 Estimation method

The two dependent variables are qualitative, and two independent binary response models have been estimated by Maximum Likelihood.[6] Because these models are non-linear, the interpretation of a given coefficient deserves attention since its impact on the dependent variable is not obvious. We hence provide the reader with marginal effects in the last column of the tables of results. For a given explanatory variable in the model, this marginal effect thus represents how the predicted probability of the modality explained (belonging either to both coalitions or to the winning coalition) changes at the mean values of the other explanatory variables.

## 4. Results

### 4.1 Factors affecting the decision to belong to one or to both coalitions

We explore the factors affecting the decision to belong to one or to both coalitions. The dependent variable is COALITION (COALITION=1 if the company belongs to both coalitions, COALITION=0 if the company belongs to either the Blu-Ray coalition or the HD-DVD coalition). The results of the best model are given in Table 3 with some measures of fit.

[6] The current database does not allow a panel probit estimation over the 2000-2008 period as the date at which every company joined the coalitions have not yet been fully retrieved. A better account of the time dimension is one of our future research perspective.

**Table 3 Estimation of the probability of belonging to one or to both coalitions (n=197)**

| **Parameter** | **Estimate** | **Std Err** | **Student t** | **Pr > \|t\|** | **Marginal effect** |
|---|---|---|---|---|---|
| Intercept | -69.0681 | 27.0219 | -2.56 | 0.011 | - |
| ASIA | .8958 | .3842 | 2.33 | 0.020 | .1604** |
| ONLINE | 1.4901 | .3233 | 4.61 | 0.000 | -.2717*** |
| FORMATFOUNDER | .57909 | .2265 | 2.56 | 0.011 | .1056** |
| RELATEDNESS | 38.409 | 15.5307 | 2.47 | 0.013 | 7.0038*** |
| $(\text{RELATEDNESS})^2$ | -5.4344 | 2.2308 | -2.44 | 0.015 | -.9910*** |

Log-likelihood: -99.52 LR test of nullity(5): 34.28 p-value < 0.0001
Mc Fadden LRI: 0.1469 Maddala Pseudo $R^2$: 0.3214 % of correct predictions: 82.2

***: p-value < .01, ** : p-value <.05

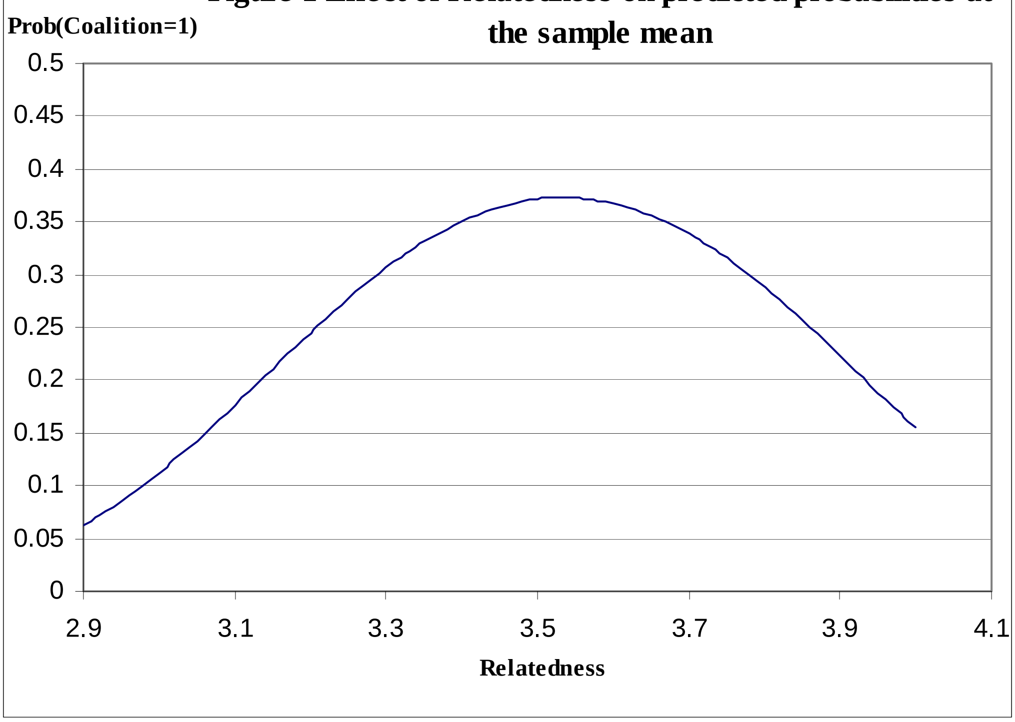
The overall quality of the model is satisfactory, the two measures of fit are correct and the model correctly predicts the decision in 162 out of 197 cases (82.2%) with a cut-off at .42. Three control variables as well as a quadratic function of RELATEDNESS are significant.

Among the control variables, being an Asian firm **(ASIA)**, being a "NationWide retail and major online support" (**ONLINE**), or being a format founder and competitors (**FORMATFOUND**) positively influence the probability of belonging to both coalitions. Hence, *ceteris paribus*, belonging to an Asian country (ASIE) significantly increases the probability of belonging to both coalitions by 16%, being an ONLINE support increases the probability of belonging to both coalitions by 27% and belonging to the FORMATFOUNDER group increases this probability by 10.6%.

Analyzing of the effect of **Relatedness** is problematic due to its non-linearity and due to the intrinsic non-linearity of any binary response model. We represent its effect in Figure 1, where the probability of success is computed over the entire range of the relatedness variable (i.e. from 2.84 to 3.98), and at the mean values for the other explanatory variables (ASIE=0.532995, ONLINE=0.071066 and FORMATFOUND=0.172589).

We observe that the marginal effect of relatedness follows an inverted-U relationship (an increase in the average relatedness increases the probability of belonging to both coalitions up to 3.53, and then decreases it). More formally, a 10% decrease in the average relatedness, from 3.53 to 3.18, lowers the probability of belonging to both coalitions by 14.8% and a 10% increase, from 3.53 to 3.8, lowers this probability by the same amount.

**Figure 1 Effect of Relatedness on predicted probabilities at the sample mean**




## 4.2 Factors determining the success of the standard

The factors determining the success of a standard are explored. The decision is also modelled by Maximum Likelihood (ML) using a binary Logit model. The dependent variable is SUCCESS (SUCCESS =1 if the company belongs to the winning coalition, and 0 otherwise). The results of the best model are given in Table 4 with some measures of fit.

**Table 4 Estimation of the probability of belonging to the successful coalition (n=132)**

| Parameter | Estimate | Std Err | Student t | Pr > \|t\| | Marginal effect |
|---|---|---|---|---|---|
| Intercept | 1623.231 | 446.26 | 3.64 | 0.000 | - |
| Ln(Revenue2007) | .197067 | .09191 | 2.14 | 0.032 | .0196* |
| RELATEDNESS | -1433.314 | 392.95 | -3.65 | 0.000 | -143.172*** |
| $(\text{RELATEDNESS})^2$ | 419.5879 | 114.69 | 3.66 | 0.000 | 41.912*** |
| $(\text{RELATEDNESS})^3$ | -40.7158 | 11.09 | -3.67 | 0.000 | -4.067*** |

| | | |
|---|---|---|
| Log-likelihood: -50.60 | LR test of nullity(4): 23.96 | p-value < 0.0001 |
| Mc Fadden LRI: 0.1915 | Maddala Pseudo $R^2$: 0.2984 | % of correct predictions: 84.1 |

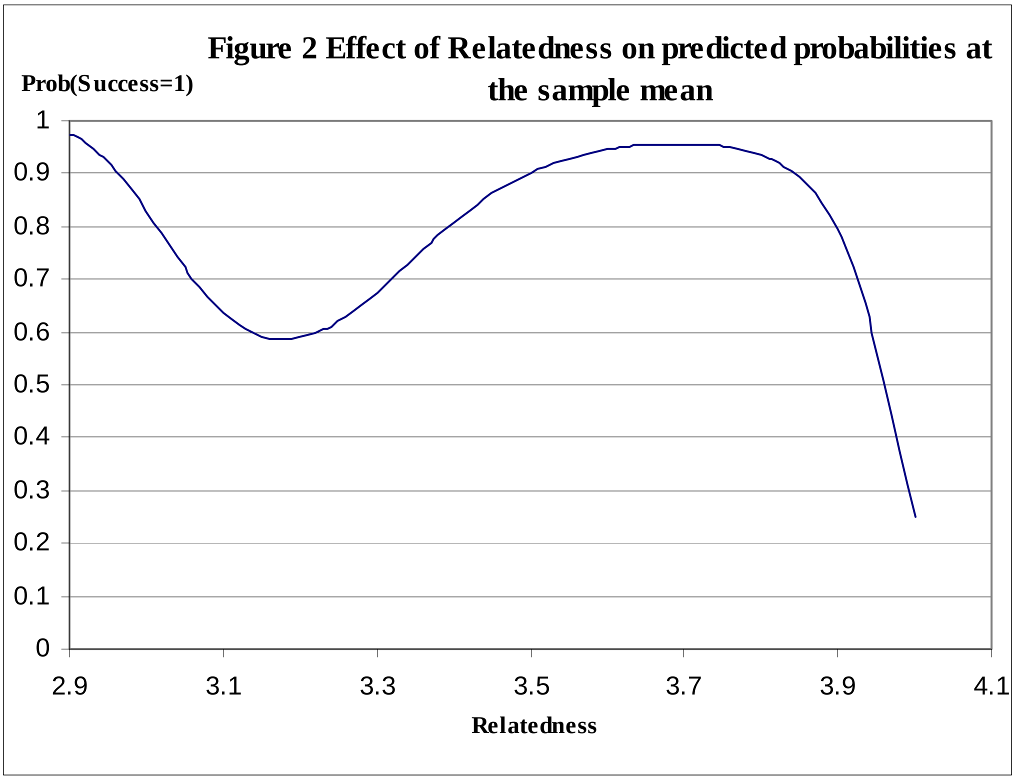
***: p-value < .01, ** : p-value <.05, *: p-value<.1

The overall quality of the model is satisfactory, the two measures of fit are correct and the model correctly predicts the adoption in 111 out of 132 cases (84.1%). Two variables appear as significant: a logarithmic function of revenue and a cubic function of RELATEDNESS.

Among the variables standing for the size and network effects, only the revenue variable appears as significant. The best model is obtained with the **logarithm of the 2007 revenue**, which is significant with a positive coefficient. This supports Hypothesis 2a: an increase in the Log (revenue2007) by one unit increases the probability of belonging to the successful coalition by 1.97%.[7]

Finally, the effect of **Relatedness** is shown in Figure 2, where the probability of success is computed over the entire range of the relatedness variable (i.e. from 2.84 to 3.98), and at the mean values for the other explanatory variable (LnRevenue2007=6.742).

We observe that the marginal effect of relatedness is roughly decreasing (an increase in the average relatedness decreases the probability of success) but in a non-linear way. Indeed, there is a portion of the range (between 3.2 and 3.7) where the effect is increasing. This finding can be contrasted with Sapienza et al. (2004), who found an inverted U-shaped relationship between sales growth and technological and production knowledge-relatedness (but no significant relationship with marketing knowledge-relatedness). Overall, the closer the code SIC (and hence the greater the similarity of the members of the coalition), the higher the probability of success, which supports Hypothesis 3.




[7] Note that we also estimated models with the log of the revenue for all years between 2000 to 2008. We obtained similar results: a marginal effect of log (revenue) on the probability of success, ranging from 1.3% in 2000 to 2.2% in 2006. This effect is significant at 5% for all years except 2000 and 2001. An interesting possibility is a potential endogeneity between the revenue of a company in a given year and the future success of the standard. Indeed, the success may partly be due to better sales of the products adopting the standard, hence increased revenues of the companies. This issue seems difficult to explore further without using a dynamic approach that the current dataset does not allow.

## 5. Implications and conclusion

An extensive literature on standardization exists, but says little about how firms choose to join standard-setting coalitions nor about the determinants of coalition success. Our work attempts to fill this void by examining the circumstances under which firms prefer to join two coalitions instead of one, and the factors that explain the success of standard-setting coalitions. We focus on the Blu-ray vs. HD-DVD standard war in the electronic video market. By considering the standard-setting coalition as a bipartite network, this study provides empirical support for the effect of prior alliances, network effect and coopetitive behavior. We find evidence that coalition size and coopetitive behavior are important in determining patterns of standard-setting success.

Our findings with regard to relatedness do indeed correspond to expectations rooted in the coopetitive rationale. The higher the similarity of the members in the coalition, the greater the probability of standard coalition success. Furthermore, relatedness leads to a greater probability of joining both competing coalitions. However, the relatedness effect is not linear and at a given degree of knowledge difference, an opposite effect exists. This confirms the non-linearity of the relatedness effect found in Nooteboon et al. (2007)'s (U-shaped argument of cognitive distance) or Sapienza et al. (2004) (inverted U-shaped relationship of production knowledge- and technological knowledge-relatedness with sales growth). Moreover, being an Asian firm increases the probability of belonging to both coalitions. As the principal founders are Asian firms, geographical proximity seems to play a role in determining the propensity of firms to engage in innovative alliances (Narula and Santangelo, 2009). Cultural differences (Kogut and Singh, 1988) as well as psychic distance (Johanson and Vahlne, 1977; Nordstrom and Vahlne, 1994) may also be expected to play a role in coalition forming. From a transaction-cost theory perspective, it could be reasoned that the higher level of uncertainty associated with international contacts is expected to lead to an increased need for control. Because the costs of monitoring and maintaining control over a long distance are high, there is greater probability that most members of coalitions belong to the same region of the world.

Thus, the level of uncertainty will be lower when companies contract agreements with other partners located in the same economic block because they are familiar with the same economic, legal and political environment. In addition, direct relationships induce more trust, improving willingness of individuals to share knowledge (Tsai and Ghoshal 1998, Levin and Cross 2004). Furthermore, it is widely acknowledged that geographical proximity positively influences network externalities (Jaffe et al., 1993; Fujita and Thisse, 2002).

Our findings with regard to size and network effect reveal several interesting points. First, high revenues increase the probability of joining the winning coalition. Second, it appears at first glance that size of coalition has a significant effect on the probability of standard coalition success. Founders (especially electronic goods manufacturers and ITC firms) and major studio supports are likely to have been main drivers of standard coalition success in the case of the Blu-ray versus HD-DVD standard war. Interestingly, these results converge with the finding dealing with the relatedness argument. The presence of a sufficient number of similar actors respectively at horizontal and vertical axis is decisive for the standard's success. This indicates that the coopetitive behavior needs to occur not only at horizontal level but also at downstream and upstream levels; here the role of particular vertical players, in this case the Hollywood studios, was crucial to the Blu-ray standard's success. This was not the case for HD-DVD, with fewer coopetitive agreements, mainly at the downstream level. Third, it emerges that founders and some major co-sponsors will act as attractors for other companies and consequently prefer to belong to one coalition rather than both whereas some downstream and/or upstream leading, as well as smaller companies prefer to act as followers and bet on both coalitions. Some of the latter will subsequently abandon one coalition and only remain in the coalition whose standard tends to draw positive feedback, "tipping" to a single winner.

In fact, one key reason why Toshiba stopped developing, manufacturing, and marketing HD-DVD players in February 2008 is that several leading co-sponsors decided to stop supporting the HD-DVD format. Hollywood majors gradually abandoned the HD-DVD coalition to join the Blu-ray coalition, which led Toshiba to announce its withdrawal from HD-DVD. Among the Hollywood majors, only Warner Bros and Paramount Pictures abandoned HD-DVD in 2008. Similarly, Microsoft's decision to back HD-DVD and Apple's commitment in favor of Blu-ray were weighty decisions for both alliances, as both are major players in their respective fields. The presence of major players in the coalition, especially suppliers of complements and co-sponsoring firms, is likely to increase coalition success by strengthening its ability to impose its standard (Backhaus et al., 2009). However, results on size effect will require further confirmation and more in depth analyses need to be undertaken before we can be fully conclusive. Note that our findings indicate that firms joining a standard-setting initiative have incentives to be part of the same coalition because their collective actions will ultimately affect the standard's chances of success.

Moreover, we find that neither past collaboration nor experience significantly affects the probability of standard success or belonging to both coalitions. Furthermore, variables dealing with innovation (patents and R&D expenditure) do not seem to significantly affect standard coalition success. One key explanation is the symmetry of the coalitions in terms of innovation: both include major information communication technology firms and electronic goods manufacturers with a strong innovation base.

In addition, empirical evidence supports the findings by Duysters and Lemmens (2008), that not every firm can join a standard setting coalition. Rather, the standard-setting coalition is carefully composed, with large founding firms selecting technologically similar firms (relatedness) to add to the unique innovative capabilities of the group. Because of these selection mechanisms, competing for specific partners and their distinct technologies will even enforce the group-based competition in the coalition (Duysters and Lemmens, 2008).

These findings have implications for management. First, they support the hypothesis that both size and network effect are crucial to standard coalition success. Thus, firms should join the largest coalition. Second, our findings indicate that a broad coopetitive standardization approach is more beneficial than concentrating on only a few selected cooperative arrangements. Further, the coopetitive approach should involve both downstream and upstream actors. Yet one noteworthy finding from the results is that a contained form of coopetition is to be recommended. In support of Hypothesis 3, we find that the greater the similarity of the members in the coalition, the higher the probability of success; but the marginal effect of relatedness evolves in a non-linear way, indicating that a critical number of similar actors at multidimensional levels is required. Finally, to gain competitive advantage it is advisable to influence and attract these actors (suppliers of complements and co-sponsors), offering them sufficient incentives to join one coalition and discouraging them from supporting rival coalitions (Besen and Farrel, 1994; Soh, 2010).

Although the geographical proximity effect has not been covered in this paper *per se*, it appears from the results (the nationality of the partner) as well as from the social distance argument that companies could learn and earn a lot through cooperation with direct competitors to build a market and set up a successful standard. Thus, firms could widen their knowledge portfolio and further strengthen their knowledge base. However, there is a drawback: as firms cooperate with direct competitors, the risk of losing their competitive position through outflow of their own knowledge to competitors (Singh, 2004) increases. We indeed confirm the multiple dimension of the degree of knowledge difference previously found (see Nooteboon et al., 2007; or Sapienza et al., 2004) but we obtain a more complex pattern than the mere U-shaped (or inverted U-shape) relationship between knowledge-relatedness and a coalition's standard success. This issue is worth exploring in further detail.

Finally, this paper has some limitations. First, some missing data limit the number of partners used in the econometric estimations. Second, we take coalition as a bipartite network. This is a handicap that prevents a deep analysis of social distances between coalitions' memberships at dyad level and the capture of more structural network effects. This may explain the result obtained regarding Hypothesis 1 (no significant link between the number of past alliances and the probability of success). This also prevents us from exploring how the geographical proximity effect impacts the decision to choose one coalition, as well as its probability of success.

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## APPENDIX 1 – Descriptive statistics (n=261)

| Variables | Mean | Stand.- Dev. | Min. | Max. | Missing |
|---|---|---|---|---|---|
| SUCCESS (=1) | 0.73181 | 0.44387 | 0 | 1 | 0 |
| COALITION=1 | 0.25287 | 0.43549 | 0 | 1 | 0 |
| ASIA (=1) | 0.52451 | 0.50063 | 0 | 1 | 57 |
| NORTH-AMERICA (=1) | 0.32353 | 0.46897 | 0 | 1 | 57 |
| EUROPE (=1) | 0.15196 | 0.35987 | 0 | 1 | 57 |
| FORMATFOUNDER (=1) | 0.09195 | 0.28896 | 0 | 1 | 0 |
| MOVIE (=1) | 0.05747 | 0.23274 | 0 | 1 | 0 |
| ONLINE (=1) | 0.02682 | 0.16156 | 0 | 1 | 0 |
| MAJOR (=1) | 0.01149 | 0.10659 | 0 | 1 | 0 |
| MISCELLANEOUS (=1) | 0.81226 | 0.39050 | 0 | 1 | 0 |
| PATENTS_Delphion (overall number on 2000-2008) | 9563.713 | 23136.37 | 0 | 122330 | 118 |
| PATENTS_USPTO (overall number on 2000-2008) | 712.601 | 2784.297 | 0 | 18013 | 118 |
| RELATEDNESS (average) | 3.43706 | 0.32494 | 2.844 | 3.975 | 57 |
| SOCIALDistance (number) | 9.84762 | 23.6963 | 0 | 112 | 156 |
| PASTCollaboration (number) | 38.0149 | 86.1237 | 0 | 542 | 127 |
| ALL-TIES (number) | | | | | |
| EMPLOYEES in 2000 (in thousands) | 53.31156 | 140.0953 | 0.055 | 1400 | 156 |
| EMPLOYEES in 2007 (in thousands) | 62.28357 | 214.2614 | 0.047 | 2100 | 156 |
| REVENUE in 2000 (USD millions) | 7317.768 | 20296.18 | 0 | 192003 | 141 |
| REVENUE in 2007 (USD millions) | 17093.12 | 62444.13 | .833 | 546274.1 | 134 |
| R&D expenditure in 2000 (USD millions) | 297.567 | 714.639 | 0 | 4006 | 163 |
| R&D expenditure in 2008 (USD millions) | 502.508 | 1189.63 | 0 | 8164 | 150 |
| PERCREV (in percentage) | 445.749 | 2046.65 | -85.98 | 16511.76 | 151 |
| PERCR&D (in percentage) | 357.789 | 2179.74 | -100 | 21950 | 118 |