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Is it Really a Universal Phenomenon? - Preferential Attachment in Alliance Networks

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We study preferential attachment (i.e., a rich-get-richer effect) in alliance networks. Thereby, we argue that various levels (firm, firm group, country) influence the strength of preferential attachment. To test our hypotheses, we take a sample of 117 airlines from 74 countries in the period 2001 to 2011. For the estimation, we use stochastic actor-oriented models, a method for analyzing longitudinal network data. As a result, we find that preferential attachment is stronger for firms that have fewer resources and are located in a less-developed country. Consequently, we show how different competitive positions affect alliance strategies.

Keywords: strategic alliances; airline industry; network analysis; preferential attachment; network evolution; stochastic actor-oriented models

Introduction

Alliance network structures and their evolution significantly influence firm performances (Baum et al., 2012; Wu et al., 2018). As a key mechanism of network evolution, preferential attachment describes a rich-get-richer effect in the transformation of networks (Barabási and Albert, 1999). More precisely, preferential attachment refers to the phenomenon where having many relationships leads to an even greater relationship formation rate. In the context of strategic alliances, preferential attachment means that firms with a high alliance portfolio size form more additional alliances (compared to firms with a low alliance portfolio size). Several studies demonstrated that preferential attachment is an important driver of alliance network evolution (Gulati, 1999; Gay and Dousset, 2005; Rosenkopf and Schilling, 2007; Mamavi and Meier, 2014; Corbo et al., 2016). Yet, the existing literature treated preferential attachment as a universal phenomenon that works in the same way for all members in a network, but we strongly doubt this view. Related research has shown that the impacts of alliance portfolio size on firm performance are contingent on various aspects like firm strategy, firm size, industry environment, or the institutional country framework (Lahiri and Narayanan, 2013; Wang

et al., 2015). As a consequence, we adopt this contingency view and show that preferential attachment is also dependent on several features of the firm and its environment. Hence, we try to answer the question: Is preferential attachment really a universal phenomenon in alliance networks or does it affect different firms differently?

The alliance formation literature revealed three levels – connected to three distinct theoretical views – that are able to affect endogenous network processes (i.e., resulting from the current network of relationships) like preferential attachment. At the firm level, the resource-based view argues that firm resources affect the capabilities and motivation to form alliances (Lavie, 2006). On the group level, the relational view assumes that a firm's embeddedness in a group of firms influences its alliance strategy (Dyer and Singh, 1998). At the country level, the institution-based view claims that the alliance behavior is the result of the home country institutional development (Peng, 2002). These views on alliance formation are not mutually exclusive (Peng et al., 2009). Rather, they complement each other in order to explain alliance network evolution. We argue that all three levels mutually influence preferential attachment in alliance networks.

We contribute to the alliance literature in several ways. A deep understanding of endogenous network processes like preferential attachment is crucial for scholars and managers (Castro et al., 2014; Corbo et al., 2016). It delivers insights about the behavior of firms and managers, which is necessary in order to draw inferences

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on performance implications (Ahuja *et al.*, 2012). Furthermore, CEOs, industry cluster representatives, and alliance managers need to understand the endogenous mechanisms of network evolution if they want to design successful cooperation strategies (Koka *et al.*, 2006). Planning alliance strategies without incorporating the future changes of the network could result in a harmful mismatch between strategy and environment. Our study contributes to the understanding of endogenous network processes by for the very first time analyzing the contingency conditions of preferential attachment in alliance networks. More precisely, our results indicate that especially firms in weak competitive positions can use their current alliance portfolio in order to design successful alliance strategies and initiate competitive actions. For example, it could be fruitful for small firms from developing countries to invest early into one or two alliances if they have international growth ambitions. A few years later, during the internationalization process, these alliances might set the base for a rapid internationalization strategy using alliances with many partners. In addition, we contribute to the resource-based view, the relational view, and the institution-based view by demonstrating how they explain the dynamics in interorganizational networks. Thereby, we argue that all three views set boundary conditions for the behavior in alliance networks. The competitive advantages explained by these views are able to substitute competitive advantages originating from social capital (e.g., alliance portfolio).

In our theory section, we outline very briefly our well-studied baseline hypothesis regarding the direct effect of preferential attachment. Afterwards, we focus on our three moderator hypotheses. To test our assumptions, we take an unbalanced network panel dataset of 117 airlines and their codeshare alliances in the period from 2001 to 2011. We estimated the change of network structures using SIENA, an implementation of stochastic actor-oriented models designed to test for endogenous network processes (Snijders *et al.*, 2010a, 2010b).

Theory

Preferential attachment

Several studies have shown that preferential attachment is a significant process in alliance networks (Gulati and Gargiulo, 1999; Gay and Dousset, 2005; Rosenkopf and Schilling, 2007; Mamavi and Meier, 2014; Corbo *et al.*, 2016). Hereby, a large alliance portfolio increases the alliance formation activity in the future. Preferential attachment takes place from two sides. On the one hand, there is the attractiveness effect of large alliance portfolios. Having many alliance partners leads to a higher reputation

(Gu and Lu, 2014) and more network resources (Gulati, 1999). Potential partners are more willing to ally with the focal firm because it has already proved to be a reliable trustworthy partner and has valuable connections to third parties.

On the other hand, there is the ability effect. Large alliance portfolios could (under certain conditions and with sufficient capabilities) increase a firm's performances (Duysters *et al.*, 2012; Wang *et al.*, 2015). The generated financial and innovative resources can be used to establish new alliances. Moreover, large portfolios ease the creation of new alliances by strengthening the power in the network (Yeniyurt and Carnovale, 2017) and granting access to potential partners (Walter *et al.*, 2007). Additionally, the existing alliances create experiences that advance the alliance management capabilities (Heimeriks *et al.*, 2009). These capabilities ease the creation of alliances to new partners (Haider and Mariotti, 2016). In conclusion, the attractiveness and ability effects lead to our baseline hypothesis:

Hypothesis 1. Preferential attachment affects the evolution of alliance networks. Hence, a large alliance portfolio size increases the alliance formation rate.

Nonetheless, attractiveness and ability effects of large portfolios do not work in the same way for all actors in a network. Attractiveness effects function by signaling a firm's value to potential partners. However, the value and strength of signals in alliance networks diminishes, when a firm generates comparable signals through other sources (Reuer and Ragozzino, 2014). Similarly, the ability effects only work if a firm does not already possess the respective abilities due to another reason. For example, a small unknown IT-startup from Central America probably behaves in the logic of preferential attachment, when it comes to alliances. Attractiveness and ability effects strongly benefit from this type of firm. However, this may not be true for a US-based competitor like IBM. A strong international reputation and alliance management capabilities that have been developed over a long period of time ease the creation of new alliances for IBM. Furthermore, the stability of the US economy helps to attract alliance partners. Preferential attachment becomes less important.

In sum, we argue with a classical substitution effect. The process of preferential attachment becomes weaker when a firm receives the relevant benefits of alliance portfolios (e.g., reputation, power, network resources, access to potential partners, experiences, alliance management capabilities) elsewhere. These benefits of alliance portfolios can be best explained by the three major theoretical views on alliance formation: the resource-based view, the relational view, and the institution-based view.

Preferential attachment and firm resources

According to the resource-based view, firm resources are a central determinant of firm behavior in alliance networks (Lavie, 2006; Yin *et al.*, 2012). It states that a firm's alliance strategy is dependent on the internal and external resources. Consequently, we argue that firm resources (e.g., production capacities, a broad distribution network, innovative capabilities, etc.) influence preferential attachment by substituting the attractiveness and ability effects of large portfolios.

Regarding the attractiveness effects, having many resources usually comes with an enhanced firm reputation (Fombrun and Shanley, 1990). This enhanced visibility makes it easier to attract alliance partners. Moreover, working with resourceful firms seems less risky for potential partners (Andreuski *et al.*, 2016). That is because resourceful firms usually obtain more prominent market positions, which functions as safeguard against unethical behavior towards the stakeholders (e.g., alliance partners). Additionally, the attractiveness effect or large portfolio is simply reduced by the resources themselves. A resourceful firm is attractive to partners because it can provide benefits through its resources. This substitutes the external resources of large alliance portfolios.

Resources also substitute the ability effect of large portfolios. Similarly to firms with many alliance partners, firms with many resources tend to have higher power in interfirm networks (Porter, 1980) and more experienced top management teams (Sambharya, 1996). Furthermore, the resourcefulness allows the creation of a dedicated alliance function, which increases the ability to form alliances (Kale *et al.*, 2002).

Hypothesis 2. Firm resources negatively moderate the relationship between alliance portfolio size and the alliance formation rate (i.e., preferential attachment).

Preferential attachment and firm group membership

Next, we focus on the level of firm groups and take a relational view. It considers the firm affiliations as a primary source of competitive advantage and firm behavior (Dyer and Singh, 1998). Consequently, the embeddedness in a group of firms influences the formation of strategic alliances (Ozmel *et al.*, 2013; Sullivan and Tang, 2013). We define firm groups very broadly as clusters of legally independent firms in an industry that are tied together through rules, norms, or contracts (Granovetter, 1995). They frequently share resources, brands, technologies, or competences in order to be more competitive (Chang and Hong, 2000; Capaldo and Petruzzelli, 2014). Examples of firm groups include industry associations, constellations, cluster organizations, and business groups.

Firm groups affect preferential attachment by influencing the attractiveness effects of large portfolios. These groups increase their members' reputations, provide network resources, expand alliance experiences, and improve alliance capabilities (Chang and Hong, 2000). Subsequently, large portfolios lose their value as signals of attractiveness. The signaling value is displaced by the group membership (Reuer and Ragozzino, 2014). Moreover, non-member firms with large portfolios are more attractive to potential partners (compared to firms with the same portfolio size, but a group affiliation) since their portfolio possesses more ties that are non-redundant. On the contrary, network structures within firm groups tend to be overly cohesive (Lai, 1999). As a result, group members with a large portfolio are less attractive because much of their social capital is also accessible by an alliance to another member of the group.

Similarly, firm groups have an impact on the ability effects of large portfolios. They facilitate the access to information about potential partners (Gulati and Gargiulo, 1999) and increase power (Claessens *et al.*, 2000). Both substitute the ability benefits of large portfolios. In addition, the portfolio size of member firms partially becomes a function of the group (Chen and Chang, 2016). The group (members) may channel the possibilities to form new alliances (Heidl *et al.*, 2014). Take for example the wine industry. A vineyard that is a member of a winemaking cooperative cannot enter into a new marketing alliance independently. Marketing activities are often centered at the winemaking cooperative that decides about new marketing alliances. Consequently, preferential attachment cannot take place.

Hypothesis 3. Firm group membership negatively moderates the relationship between alliance portfolio size and the alliance formation rate (i.e., preferential attachment).

Preferential attachment and home country institutional development

Finally, we analyze the country level and pursue an institution-based view. It argues that institutional settings in a country influence the determinants of doing business (Peng, 2002). Recently, scholars have emphasized the influence of home country institutional development on alliance formation (Roy, 2012; Choi and Yenyurt, 2015; Choi and Contractor, 2016). We define institutional development as the degree to which the economic, political, and social conditions in a country are beneficial for organizations and people (North, 1990). For instance, a country with less-developed institutions (e.g., Pakistan or Venezuela) might suffer from an ineffective

prosecution, non-transparent political processes, or a strong shadow economy.

Like previously, we argue that home country institutional development substitutes the attractiveness effects of large portfolios. Especially when it comes to international alliances, well-developed home countries (e.g., Switzerland or Canada) increase the attractiveness to potential partners (Meyer, 2001). Institutional achievements like a jurisdiction that effectively guarantees the enforcement of business contracts substitutes the reputation as a trustworthy partner, which arises from large alliance portfolios.

On the contrary, in less-developed countries, the absence of functioning institutions reduces the willingness of foreign firms to make investments in partnerships (Arregle *et al.*, 2013). In these countries, high levels of corruption and state despotism create an unfavorable environment for cooperation (Woo and Heo, 2009). Due to the uncertainty and missing governance codes, reputation becomes a main instrument to increase interfirm trust (Nielsen, 2003; Gu and Lu, 2014). Large alliance portfolios can improve the firm reputation, which consequently enables preferential attachment in these countries (Giuliani, 2013). Moreover, large alliance portfolios also compensate the low availability of information in less-developed markets. Potential foreign partners can use the existing partners of a firm as a source of information about the local firm (Nicholson *et al.*, 2005), which leads to preferential attachment for the local firm.

Similarly, home country institutional development substitutes the ability effects of large portfolios. Like large alliance portfolios, countries with highly-developed institutions help firms to build alliance management capabilities by creating incentives to operate internationally (Hitt *et al.*, 2004) and by providing a stable environment (Mukherjee *et al.*, 2013). Furthermore, firms from developed countries frequently possess technical knowledge necessary for creating new R&D alliances, since their home countries are the home to productive universities and other research facilities that share their knowledge with local firms (Hitt *et al.*, 2000). In contrast, firms from less-developed countries often need to acquire this knowledge through their current alliance portfolio. Finally, firms in highly-developed countries can rely on well-working financial institutions in order to finance the operations in strategic alliances (Ahlstrom *et al.*, 2014). However, firms in less-developed markets are more dependent on their existing alliance partners, since they could function as a source of financial capital (Gopalakrishnan *et al.*, 2008).

Hypothesis 4. Home country institutional development negatively moderates the relationship between alliance portfolio size and the alliance formation rate (i.e., preferential attachment).

Methods

Sample

For the analyses, we used a panel dataset from the airline industry. The industry fits well to test our hypotheses because it: (1) consists of firms with similar business models; (2) possesses a high importance of strategic alliances; and (3) has long-lasting and relevant firm groups (Doganis, 2006). Our sample contained 117 airlines from 74 countries with annual data from 2001 to 2011. The panel was unbalanced (58 airlines are present in all periods, 59 only in a subset of periods).

For the sample, we selected all the airlines with sufficient data coverage in the annual airline alliance surveys published by the journal *Airline Business*, which serves as a main data source for analyzing the airline industry (Mitsubishi and Min, 2016; Cobeña *et al.*, 2017; Rossmannek and Rank, 2019). We concentrated on “full service carrier” airlines. Hence, we did not include airlines with non-traditional strategies (cargo, low cost, leisure, and charter) because these airlines generally demonstrate a very different and unique cooperation behavior (Morandi *et al.*, 2015). Additionally, we deselected all airlines where the reports of the journal *Airline Business* did not provide data for consecutive years (in order to be able to analyze network evolution). As a result, our sample contained between 66% and 81% of the annually flown passengers by the leading 200 airlines in the world. The time span from 2001 to 2011 included major industry events, their aftermaths, and the following recreations (e.g., 9/11 and the World Financial Crisis). Consequently, the time horizon seemed to picture several states of the industry.

Firm-specific data originated from *Airline Business*, corporate websites, the Lexis Nexis database, and Gaggero and Bartolini (2012). Country-specific data was gathered from the World Bank (Kaufmann *et al.*, 2009), the CEPII research center (Mayer and Zignago, 2011), and national statistics bureaus.

Analyses

For a better understanding, we describe the method prior to the variable operationalization. We used SIENA, the implementation of stochastic actor-oriented models (Snijders *et al.*, 2010a, 2010b). These models analyze network evolution as specified in our hypotheses (Ripley *et al.*, 2020). For our purpose, SIENA was more suitable than traditional methods (e.g., regression analyses). It estimates network evolution based on endogenous network processes and exogenous characteristics of actors. Subsequently, SIENA does not view actors as isolated individuals. It also accounts for the relationships to other actors and their characteristics, which is a more

realistic approach for longitudinal alliance data (Kim *et al.*, 2016). The baseline assumptions of SIENA are well-suited for networks in which all actors know each other and are able to decide autonomously about relationships. This corresponded well to the intra-industry alliance network that constitutes our sample. Our model choice is in line with other scholars that used SIENA to analyze the evolution of alliance networks in recent time (Ebbers and Wijnberg, 2010; Castro *et al.*, 2014; Corbo *et al.*, 2016).

Strategic alliances are undirected relationships in which the exchange is reciprocal. The establishment of an alliance is usually proposed by one actor and approved by the other one. A termination can originate from just one actor (van de Bunt and Groenewegen, 2007). Therefore, we chose unilateral initiative and reciprocal confirmation as modeling process in SIENA. Moreover, our sample is unbalanced. SIENA offers two possibilities for dealing with the composition change (Ripley *et al.*, 2020). We selected the method of structural zeros for this purpose since the competing method of Huisman and Snijders (2003) did not result in a stable model. Furthermore, we used method of moments estimation, which is comparable to maximum likelihood estimation using larger sample sizes like we do (Snijders *et al.*, 2010a, 2010b).

SIENA does not estimate the emergence of the network in the first year (period 0). It analyzes the subsequent changes between periods. Therefore, it uses the variables (and some random error) to calculate the likelihood of creating, maintaining, and terminating a tie. The variables could be endogenous (originating from the network) or exogenous (originating from the actors). Exogenous variables can either be actor-based (e.g., firm resources) or express the dyadic relationship between two actors (e.g., geographic distance between firm headquarters). Both types could be either stable or change every period. In contrast to regression analyses, the variables are not added directly to the model, but are the bases for effects. Effects account for different ways in which a variable influences network evolution. Subsequently, there could be more than one effect for a variable. The sum of the effects constitutes the objective function, which is an indicator for the likelihood with which an actor forms its network in a certain way (Ebbers and Wijnberg, 2010).

Variables and effects

The dependent variable was the network of strategic alliances. We operationally defined an alliance as a codeshare agreement between two airlines (Corbo *et al.*, 2016; Mitsuhashi and Min, 2016). Hereby, airlines put their flight number on flights of partner airlines and vice versa (Gleave, 2007). This enables them to share resources and passenger information (Casanueva

et al., 2014). The concentration on codeshares allowed a good comparability between firms because codeshares are a quite standardized form of alliances. Therefore, we ensured that firms do not use different types of governance structures, since equity governance structures can substitute the mechanisms that enable preferential attachment (Li and Ferreira, 2008).

We generated a 117×117 matrix for each period, which showed if codeshares between each airline pair existed or not. All matrices were symmetric to the main diagonal because alliances are non-directed.

For the variable operationalization and effect definition, we followed (Corbo *et al.*, 2016) who had analyzed codeshare networks with SIENA before. However, we improved their approach wherever it was possible. As described above, there were different variables that constituted the effects. First of all, the network itself was a variable that provided the endogenous effects. *Rate* modeled the speed of tie changes between periods. *Degree* functioned as an intercept in a regression for the number of ties per actor. *Triadic closure* measured if an open triad tends to close in time. For example, actor A has one alliance with actor B and another alliance with actor C. However, B and C do not have an alliance with each other yet. In this case, the triadic closure effect accounts for the tendency of B and C to form an alliance. These three effects served as a baseline in order to assure a valid and stable model (Ripley *et al.*, 2020). Also, we included the *preferential attachment* effect (called ‘inPop’ in SIENA) in order to test our first hypothesis.

The rest of the effects were exogenous, that is, they originated from the sample firm’s characteristics. On the one hand, there were actor-based variables. We measured *firm resources* as an airlines’ number of planes. It was operationalized as hundreds of aircrafts possessed by the airline (Corbo *et al.*, 2016). *Firm group membership* was a dummy that indicated if the airlines belonged to one of the five big constellations in the airline industry: Star Alliance, SkyTeam, Oneworld, Wings (terminated 2004), and Qualiflyer (terminated 2002). Within the airline industry, these constellations represented the most important and visible manifestation of firm groups (Hu *et al.*, 2013). The constellations cooperated in several areas, followed collective rules, shared a brand, and had a strong influence on competition (Wang, 2014). Home country *institutional development* was one single variable composed of the six dimensions of the World Governance Indicator (WGI) published by the World Bank (Kaufmann *et al.*, 2009). All dimensions were combined through confirmatory factor analysis into one factor.¹ The WGI is a common measure for institutional development among scholars and offers a broad measurement of institutional conditions (Garrido *et al.*, 2014; Choi and Yenyiyurt, 2015).

Economic growth influences airline alliance strategies (Corbo *et al.*, 2016). Subsequently, we controlled for

home country *GDP growth* measured as percentage points. *Alliance experience* measured the years since the first alliance of an airline. It was included on the premise that experience influences the alliance management capabilities and thereby the alliance formation behavior (Rothaermel and Deeds, 2006). We also controlled for market size, which influences airlines' cooperation behavior (Vowles, 2000). Therefore, we used the home country *GDP* in billion US Dollars (Corbo *et al.*, 2016). Moreover, we controlled for an airline's *reach* (average flight distances, flights in thousand kilometers) because airlines with a focus on long or short haul flights may form alliances differently (Dennis, 2005).

For all actor-based variables, we included degree and similarity effects (Corbo *et al.*, 2016). Degree effects accounted for the number of alliances. Similarity effects measured homophily between firms (e.g., two airlines preferably formed an alliance if their number of resources was similar). Moreover, we transformed the *GDP* and the alliance experience variables by the natural logarithm in order to account for a skewed distribution.

On the other hand, there were dyadic variables that measured the relationship between two airlines. We incorporated the main effect for all dyadic variables (Corbo *et al.*, 2016). Thereby, the likelihood of having an alliance was influenced by the value of the variable. *Colony* was a dummy variable that accounted for a historical colonial link between the home countries of the two airlines. We incorporated the variable since the historical relationship between the home countries has a substantial impact on the alliance formation likelihood of two firms (Arikan and Shenkar, 2013). *Common ethno language* was also a dummy variable and stated if the airlines home countries had a common language (spoken by at least 9% of the population). Language barriers are proxies for cultural dissimilarities which complicate interfirm coordination (Brannen, 2004). The geographic distance between firms also influences the likelihood of having an alliance (Choi and Yenyurt, 2015) since it affects alliance performances (Capaldo and Petruzzelli, 2014). We included *hub distance* that measured the geographic distance in thousand kilometers between the two airlines' most important airports. Furthermore, *same country* indicated if two airlines originated from the same country. Cooperating within the home country decreases uncertainties by mitigating the liabilities of foreignness (Zhang and Pezeshkan, 2016). Moreover, we measured if an *ownership tie* between two airlines existed, which affects their cooperation activities (Fee *et al.*, 2006). For example, Air France and KLM maintain numerous codeshares because they belong to the same holding. The dummy variable accounted for direct and indirect ownership relations (joint parent company or ownership by the same government). *Same firm group* complemented the similarity effect of the

Table 1 Descriptive statistics

Type	Variable	Statistic	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Network	Network	Number of actors	103	105	106	107	102	78	79	79	78	73	69
		Density in %	7.2%	7.6%	8.1%	8.4%	9.7%	14.2%	14.2%	14.6%	15.3%	17.5%	17.6%
		Jaccard index	0.794	0.794	0.774	0.857	0.767	0.660	0.827	0.883	0.802	0.795	0.795
Dyadic (constant)	Colony	Share of all potential connections	4.9%	4.9%									
Dyadic (constant)	Common ethno language	Share of all potential connections	20.3%	20.3%									
Dyadic (constant)	Hub distance	Mean in km	8107.5	8107.5									
Dyadic (constant)	Same country	Share of all potential connections	1.8%	1.8%									
Dyadic (changing)	Ownership tie	Share of all potential connections	0.7%	0.7%	0.9%	0.8%	0.9%	1.1%	1.2%	1.1%	1.2%	1.3%	1.4%
Dyadic (changing)	Same firm group	Share of all potential connections	2.7%	2.7%	3.0%	3.2%	3.7%	7.0%	7.3%	10.6%	11.1%	13.9%	13.1%
Dyadic (changing)	GDP growth	Growth rate in %	3.2%	3.2%	3.9%	5.4%	4.7%	5.9%	5.7%	2.9%	-0.6%	4.9%	4.1%
Actor (changing)	Alliance experience	Mean time (years) since first alliance	14.3	14.3	15.2	16.0	17.2	18.7	19.0	19.7	20.7	21.7	22.5
Actor (changing)	GDP	Mean in billion US Dollar	1,485.7	1,485.7	1,594.2	1,746.5	1,972.2	2,265.1	2,641.7	3,042.3	2,823.4	3,230.6	3,437.4
Actor (changing)	Reach	Mean in km	2,230.2	2,230.2	2,263.2	2,297.1	2,323.0	2,116.0	2,245.3	2,330.8	2,338.2	2,365.9	2,432.0
Actor (changing)	Firm resources	Mean number of airplanes	77.8	77.8	79.8	80.4	84.8	108.3	110.4	114.5	119.5	124.5	137.7
Actor (changing)	Firm group membership	Share of actors in any constellation	34.3%	34.3%	32.1%	32.7%	33.3%	44.9%	46.8%	55.7%	56.4%	61.6%	62.3%
Actor (changing)	Institutional development	Mean value of WGI indicator	0.545	0.545	0.541	0.541	0.487	0.502	0.521	0.567	0.543	0.586	0.570

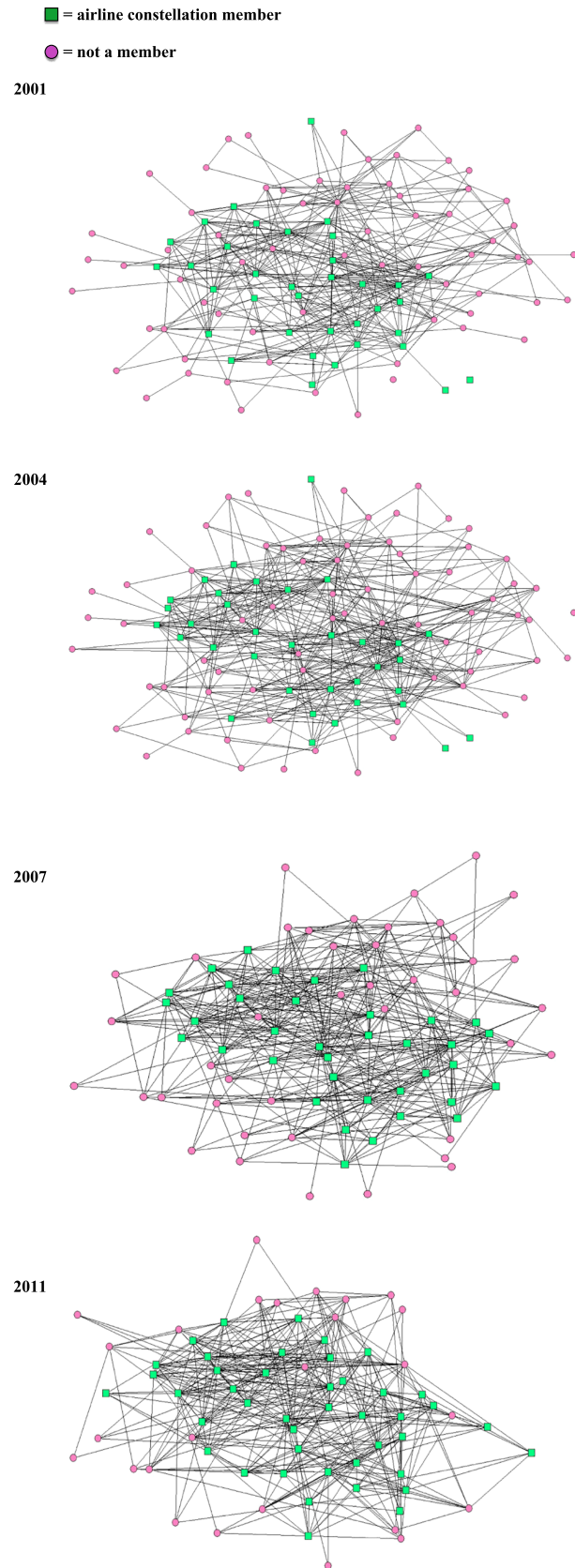


Figure 1 Snapshots of alliance network (2001, 2004, 2007, and 2011).

variable firm group membership which only measured if two airlines had a membership status in any airline constellation. Same firm group additionally stated if the airlines were in the same constellation. Airlines within a constellation preferably form codeshares (Mitsuhashi and Min, 2016). However, codeshares do not exist between all airline pairs of a constellation. In our sample, the average network density within firm groups was 66.7%.

To test our moderation Hypotheses 2–4, we created *interaction effects* that weighted the preferential attachment effect by the respective degree effects (firm resources, firm group membership, and institutional development). In SIENA, the effect to test moderation for preferential attachment is called ‘inPopX’.

Results

Table 1 shows the descriptive statistics. Moreover, Figure 1 displays several snapshots of the alliance network. Over the years, the network size decreases and the network density increases. This is mainly driven by two major industry trends. First, the airline industry witnessed several waves of consolidation (Dennis, 2005). Second, the importance of airline constellations increased, leading to more intra-group alliances.

Additionally, there is a substantial reduction in network size between the years 2005 and 2006. This is mainly caused by a methodical change in our main data source *Airline Business*. Especially firms with fewer resources and firms without firm group membership drop out of the sample. Apart from that, the characteristics of the firms seem to stay quite similar. Because we controlled for firm resources and group membership, the change of network size seems relatively unproblematic for the validity of our model. Furthermore, all the values of the Jaccard index, which measures the speed of network change, exceed the threshold of 0.6 proposed by (Snijders *et al.*, 2010a, 2010b).

Table 2 presents intercorrelations between all effects. In contrast to regression analyses, stochastic actor-oriented models do not require full independence of all effects. (Ripley *et al.*, 2020) proposed that correlations up to 0.9 are acceptable. Our model displays only very few high correlations with a maximum of 0.815. However, all correlations between the interaction effects necessary for hypotheses testing are relatively low. Therefore, hypotheses testing does not seem affected and intercorrelations are acceptable for the purpose of this study.

Table 3 reports model results. SIENA does not offer measures like R^2 that display the proportion of explained variance by different models. Consequently, we only display the full model and do not incrementally add variables. Overall, firms in our sample underlie

Table 2 Intercorrelations

<i>Effect type</i>	<i>Variable</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	Structural Density	0.499											
2.	Structural Triadic closure	0.098	-0.005										
3.	Main Colony	0.023	0.063	-0.241									
4.	Main Common ethno language	-0.363	-0.242	-0.051	0.030								
5.	Main Hub distance	-0.172	-0.125	0.050	0.050	0.277							
6.	Main Same country	0.220	0.187	-0.043	0.023	-0.124	-0.474						
7.	Main Ownership tie	0.208	-0.166	0.018	0.044	-0.250	-0.100	0.057					
8.	Degree Same firm group	-0.164	-0.180	0.049	-0.064	0.133	0.069	-0.063	-0.103				
9.	Degree GDP growth	-0.004	-0.093	0.015	-0.084	0.085	-0.075	-0.099	-0.012	0.308			
10.	Similarity GDP growth	-0.714	-0.397	-0.028	-0.075	0.426	0.277	-0.237	-0.184	0.108	-0.011		
11.	Degree Ln alliance experience	0.269	0.154	0.000	0.052	-0.240	-0.198	0.189	0.164	-0.125	-0.067	-0.424	0.254
12.	Similarity Ln alliance experience	0.284	0.380	-0.081	0.136	-0.383	-0.430	0.357	0.196	-0.118	-0.121	-0.443	0.254
13.	Degree Ln GDP	-0.235	-0.103	0.005	-0.003	0.167	-0.019	-0.107	-0.103	0.006	-0.039	0.107	-0.050
14.	Similarity Ln GDP	-0.338	-0.164	-0.076	-0.066	0.049	0.095	-0.116	-0.079	0.032	0.071	0.153	-0.149
15.	Degree Reach	-0.365	-0.199	-0.013	-0.009	0.087	-0.002	-0.059	-0.071	0.026	0.042	0.197	-0.120
16.	Similarity Reach	0.716	0.222	0.089	0.031	-0.273	0.012	0.030	0.201	-0.099	0.097	-0.420	0.279
17.	Degree Firm resources	-0.256	-0.229	-0.094	0.071	0.157	0.080	-0.032	0.068	-0.012	-0.014	0.136	-0.101
18.	Similarity Firm resources	0.526	0.461	0.039	0.080	-0.376	-0.192	0.221	-0.039	-0.048	-0.171	-0.523	0.255
19.	Degree Firm group membership	-0.394	-0.304	-0.009	-0.077	0.280	0.192	-0.194	-0.533	0.136	0.070	0.324	-0.255
20.	Similarity Firm group membership	0.370	0.280	0.044	0.045	-0.339	-0.218	0.184	0.178	0.041	0.007	-0.336	0.206
21.	Degree Institutional development	0.076	0.019	-0.063	0.040	-0.022	-0.203	0.108	0.037	-0.052	-0.220	-0.050	0.053
22.	Similarity Institutional development	0.136	0.169	0.051	0.164	-0.295	-0.12	0.141	0.314	-0.141	-0.107	-0.44	0.184
23.	Structural Preferential attachment	-0.675	-0.455	0.025	-0.126	0.354	0.313	-0.367	-0.190	0.089	0.054	0.622	-0.382
24.	Interaction Firm resources × pref. att.	-0.016	-0.170	-0.007	0.012	0.156	-0.019	0.072	-0.050	0.243	0.241	-0.095	-0.010
25.	Interaction Firm group mem. × pref. Aaatt.	-0.386	-0.364	-0.113	-0.099	0.312	0.129	-0.161	-0.293	0.082	0.006	0.479	-0.180
26.	Interaction Institutional dev. × pref. Aaatt.												

Table 2 (Continued)

	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.
1.													
2.													
3.													
4.													
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7.													
8.													
9.													
10.													
11.													
12.													
13.													
14.	-0,335												
15.	-0,028	0,048											
16.	0,020	0,021	0,708										
17.	-0,151	-0,115	-0,178	-0,234									
18.	0,065	-0,292	0,018	0,118	-0,205								
19.	0,565	-0,126	-0,030	-0,183	0,097	-0,222							
20.	-0,353	0,079	0,151	0,133	-0,183	-0,005	-0,290						
21.	0,262	-0,031	-0,189	-0,063	0,252	-0,147	0,178	-0,228					
22.	0,155	-0,067	-0,094	-0,056	-0,004	0,018	0,144	-0,210	-0,100				
23.	0,486	-0,083	-0,121	-0,169	-0,069	-0,064	0,378	-0,279	0,339	0,033			
24.	-0,608	0,182	0,116	0,086	-0,291	0,075	-0,593	0,459	-0,481	-0,143	-0,308		
25.	-0,101	0,059	0,073	0,139	-0,098	0,026	-0,210	0,026	0,150	-0,024	-0,064	-0,317	
26.	-0,429	0,030	0,103	0,171	-0,113	0,282	-0,407	0,369	-0,497	-0,013	-0,815	0,424	-0,175

Table 3 Results for analyses with SIENA ($n = 117$; 11 periods; unbalanced panel; method of moments estimation; undirected network; unilateral initiative and reciprocal confirmation model)

	Variable type	Variable	Effect type	Estimate	Std. Error	Indicated measurement of effect
1	Network	Period 1	Rate	0,914	(0,103)	Average change of network ties per airline between two periods
2	Network	Period 2	Rate	1,18	(0,120)	
3	Network	Period 3	Rate	0,721	(0,090)	
4	Network	Period 4	Rate	1,094	(0,112)	
5	Network	Period 5	Rate	0,712	(0,088)	
6	Network	Period 6	Rate	0,862	(0,114)	
7	Network	Period 7	Rate	0,548	(0,087)	
8	Network	Period 8	Rate	1,27	(0,137)	
9	Network	Period 9	Rate	0,976	(0,120)	
10	Network	Period 10	Rate	0,471	(0,084)	
11	Network	Density	Structural	-0,828*	(0,411)	Comparable to an intercept in regression analysis
12	Network	Triadic closure	Structural	0,385***	(0,039)	Closure of open triads in the overall network
13	Dyadic (constant)	Colony	Main	0,245	(0,186)	Homophily regarding an historical colonial link
14	Dyadic (constant)	Common ethno language	Main	0,292**	(0,110)	Homophily regarding joint home country language
15	Dyadic (constant)	Hub distance	Main	-0,083***	(0,013)	Influence of geographic distance on dyadic tie formation
16	Dyadic (constant)	Same country	Main	-0,804*	(0,383)	Homophily regarding joint home country
17	Dyadic (changing)	Ownership tie	Main	1,614***	(0,345)	Influence of dyadic ownership relation on dyadic tie formation
18	Dyadic (changing)	Same firm group	Main	1,617***	(0,249)	Homophily regarding same airline constellation membership
19	Actor (changing)	GDP growth	Degree	-0,016	(0,022)	Influence of home country economic growth on number of ties
20	Actor (changing)	GDP growth	Similarity	0,071	(0,544)	Homophily regarding home country economic growth
21	Actor (changing)	Ln alliance experience	Degree	-0,713**	(0,267)	Influence of experience with alliances on number of ties
22	Actor (changing)	Ln alliance experience	Similarity	0,194	(0,388)	Homophily regarding experience with alliances
23	Actor (changing)	Ln GDP	Degree	0,177†	(0,104)	Influence of home country market size on number of ties
24	Actor (changing)	Ln GDP	Similarity	0,295	(0,372)	Homophily regarding home country market size
25	Actor (changing)	Reach	Degree	-0,097	(0,097)	Influence of average flight length on number of ties
26	Actor (changing)	Reach	Similarity	-0,32	(0,580)	Homophily regarding average flight length
27	Actor (changing)	Firm resources	Degree	0,819†	(0,475)	Influence of firm resources on number of ties
28	Actor (changing)	Firm resources	Similarity	0,023	(0,483)	Homophily regarding firm resources
29	Actor (changing)	Firm group membership	Degree	-0,12	(0,402)	Influence of membership in any airline constellation on number of ties
30	Actor (changing)	Firm group membership	Similarity	-0,768***	(0,128)	Homophily regarding membership in any airline constellation
31	Actor (changing)	Institutional development	Degree	0,274	(0,177)	Influence of home country institutional development on number of ties
32	Actor (changing)	Institutional development	Similarity	0,464*	(0,211)	Homophily regarding country institutional development
33	Network	Preferential attachment	Structural	0,073**	(0,024)	Hypothesis 1 (Preferential attachment in the overall network)
34	Interaction	Firm resources × pref. Aaatt.	Degree x structural	-0,113*	(0,055)	Hypothesis 2 (Firm resources negatively influences preferential attachment)
35	Interaction	Firm group mem. × pref. Aaatt.	Degree x structural	-0,068	(0,062)	Hypothesis 3 (Firm group membership negatively influences preferential attachment)
36	Interaction	Institutional dev. × pref. Aaatt.	Degree x structural	-0,153**	(0,058)	Hypothesis 4 (Home country institutional development negatively influences preferential attachment)

Note: † $p < 0.1$;
 * $p < 0.05$;
 ** $p < 0.01$;
 *** $p < 0.001$.

preferential attachment (estimate = 0.073, $p = 0.002$), confirming our baseline Hypothesis 1. Moreover, firm resources (estimate = -0.113 , $p = 0.040$) and home country institutional development (estimate = -0.153 , $p = 0.008$) both negatively influence preferential attachment, supporting 2 and 4. We found no support for our hypotheses 3 that firm group membership affects preferential attachment (estimate = -0.068 , $p = 0.269$).

Many control effects are significant indicating a decent choice of control variables. In our view, the most interesting relationships are the firm group effects. The positive and significant dyadic effect 'same firm group' shows that airlines preferably form alliances within their firm group. In addition to that, the negative and significant similarity effect 'firm group membership' demonstrates that alliances between a member and a non-member are more likely than member-member or non-member-non-member alliances.

Model convergence is excellent (Ripley *et al.*, 2020). All convergence t ratios are under 0.05 and the overall maximum convergence ratio is 0.10. Additionally, we calculated goodness of fit statistics for the degree distribution, geodesic distribution and the triad census. All three graphical plots indicate a close model fit to the data.

Discussion

In this study, we argued that firm level, group level, and country level aspects affect preferential attachment. Our results confirmed that preferential attachment is dependent on firm and country level characteristics, which may explain why some authors had troubles to confirm a preferential attachment effect in alliance networks (Powell *et al.*, 2005). More broadly, our results indicate that a lack of strong signals as an attractive alliance partner increases the value of the firm's social capital (Reuer and Ragozzino, 2014). Consequently, alliances function as network resources that substitute for shortcomings of the firm and its environment (Lavie, 2006; Wassmer and Dussauge, 2011).

However, we were not able to find a contingency effect for the group level. This non-finding seems somehow odd since firm groups have a substantial effect on a firm's alliance behavior (Yin *et al.*, 2012). One possible explanation for this non-finding could be based on the specific structure of the airline industry. Within our sample period from 2001 to 2011, the firm groups Star Alliance, SkyTeam, and Oneworld grew steadily. Over the course of time, most airlines that had already maintained a higher degree of alliance partners entered into one of these three groups. The missing of sample airlines that were not a member of a group but maintained many alliances (especially in the second half of the sample period) could partially explain the non-finding.

We contribute to the literature in several ways. For instance, we demonstrated that endogenous processes in alliance networks do not work isolated. Instead, the strength of endogenous processes is dependent on several firm characteristics. In line with this, scholars revealed that firms do not uniformly seek to obtain broker positions in an alliance network. Instead, the development stage of the industry (Gulati *et al.*, 2012) or a firm's social capital influence the tendency to obtain broker positions (Yin *et al.*, 2012). In the context of strategic alliances, such a contingency view seems also necessary when it comes to preferential attachment and other endogenous network processes (e.g., reciprocity, triadic closure, homophily). As we have shown, the contingency factors can be explained by the three major views on alliance formation: the resource-based view, the relational view, and the institution-based view. Therefore, we also contribute to all three views.

More precisely, we contribute to the resource-based view by demonstrating how the resource seeking behavior directs (alliance) strategies. Traditionally, the resource-based view argued that firms seek resources with certain characteristics (e.g., valuable, rare, inimitable, non-substitutable) in order to gain competitive advantages (Barney, 1991; 1995). Later, scholars argued that alliances can be external sources of such resources (Lavie, 2006; Wassmer and Dussauge, 2011). In this study, we showed how internal and external resources interact. As long as a firm has valuable internal resources, the firm's external resources contribute less to the overall firm strategy. In contrast, firm strategies are guided by external resources if the internal resource endowment is relatively poor. Hence, external resources can only provide a competitive advantage if they cannot be substituted by internal resources.

Furthermore, we contribute to the relational view. It argues that a firm's affiliations (e.g., alliances, business group membership, etc.) can provide competitive advantages when organized appropriately. Therefore, the partners must have complementary resources (Dyer and Singh, 1998; Dyer *et al.*, 2018). However, Wang and Li-Ying (2015) point out that the relational view lacks explanatory power when it comes to the question how different types of affiliations interact. We argued that one type of affiliation is able to restrict the strategy for the other type of affiliation. Hence, a firm must not only have complementary partners but also complementary types of affiliations.

Moreover, we contribute to the institution-based view, which argues that home countries of firms affect strategies and can provide the basis for competitive advantages (Peng, 2002; Peng *et al.*, 2009). Nevertheless, it has also been shown that institutional voids are able to reduce competitive advantages (Doh *et al.*, 2017). Our study demonstrated how firms balance advantages and voids

of institutions regarding their cooperation strategies. More precisely, firms from low-developed countries intensively use competitive advantages originating from their alliance network in order to fight institutional voids and develop alliance strategies. In contrast, firms from high-developed countries are more inclined to neglect competitive advantages originating from their alliance network since they can rely on working home country institutions.

Additionally, we contribute to the general understanding of preferential attachment in social networks and highlight the role of relationship maintenance costs. Preferential attachment eventually works uniformly in directed networks without any significant costs of relationship maintenance (Barabási and Albert, 1999). For instance, artists with many followers on their Facebook page may have a high likelihood of getting additional followers. For them, having followers often comes without any relevant costs. In contrast, it is quite different when it comes to strategic alliances, which regularly cause high costs of maintaining the reciprocal relationship (Pangarkar *et al.*, 2017). In this case, the preferential attachment effect can be substituted more easily by exogenous characteristics. Hence, the contingency perspective on preferential attachment becomes more important with higher relationship maintenance costs.

Our findings also provide important managerial implications. Most importantly, we illustrated that especially firms in weak competitive positions can use their alliance portfolio as a source of future competitive actions. For example, a small biotechnology startup that currently develops a drug could be dependent on distribution alliances in several countries, once the drug gets to the market stage. However, for a small firm with few resources it could be difficult to quickly form several alliances on a global scale. Therefore, managers may need to form one or two alliances early in the development process. The experience and contacts to third parties, which were established, may help to form the targeted distribution alliances later on.

However, for firms in strong competitive positions our results have different implications. Firm resources and well-developed home countries increase firm's alliance attractiveness. As a result, they gain more bargaining power towards potential and existing partners. This power can be used to shape the alliance governance structures like revenue sharing mechanisms in their favor (Bosse and Alvarez, 2010).

Furthermore, we outlined that the membership in a firm group could restrict a firm's alliance strategy. Therefore, the decision not to enter a group could also provide certain benefits. For example, the airline Etihad Airways chose not to join one of the major industry constellations. Instead, it built its own group of closely connected airlines

by acquiring minority stakes in its partners. Such a strategy may increase firm risks, but it improves flexibility and independence.

Nonetheless, we have to address the limitations of our research. Most importantly, our study was based on an intra-industry alliance network. Preferential attachment could work very differently in alliance networks spanning several industries or involving a broader range of actors such as local suppliers, universities, or governmental agencies (Al-Laham *et al.*, 2008). In addition, the alliance type and the industry context influence network evolution (Rosenkopf and Schilling, 2007). Codeshares (our measurement of strategic alliances) largely serve for resource sharing. Compared to R&D alliances, knowledge exchange still exists but it is less important. In our setting, preferential attachment works because large alliance portfolios provide benefits like firm power, reputation, or diverse resources. Future researchers need to empirically test if our expectations also hold for innovation-driven alliances. Finally, we want to emphasize that preferential attachment does only work if the firms actually want to increase their alliance portfolio size. However, firms may rather concentrate on the characteristics of the portfolio like partner complementarity (Cobeña *et al.*, 2017), geographic proximity (Capaldo and Petruzzelli, 2014), or partner's resources (Chung *et al.*, 2000).

ENDNOTE

1. Factor loadings: control of corruption (0.972), government effectiveness (0.977), political stability and absence of violence (0.781), regulatory quality (0.962), rule of law (0.974), voice and accountability (0.784) Fit indices: CMIN/DF (3.207), GFI (0.977), AGFI (0.977), CFI (0.999), NFI (0.999), RMSEA (0.047)

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