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# The Performance Implications of Membership in Competing Firm Constellations: Evidence from the Global Airline Industry

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# The Performance Implications of Membership in Competing Firm Constellations: Evidence from the Global Airline Industry

*Abstract*

Constellations are alliances among multiple autonomous firms, such that these groups compete against each other in the same or similar industries for both clients and members. Although past research has evidenced the existence of constellations in several industry contexts, the performance implications of constellation membership have not been examined in detail. Following Gomes-Casseres (1994), I outline sources of membership benefits and offer novel hypotheses about how group organization—i.e., whether the constellation is explicit (based on formal, multilateral agreements) or implicit (informal clusters based on the structure of bilateral ties among firms)—affects those sources. Namely, I propose that generic group characteristics, which determine the total value generated by the group, contribute more to explaining interfirm performance differences in explicit constellations than in implicit ones. However, this effect is reversed in the case of member-specific attributes, which allow firms to better capture differential membership benefits within the same group. Thus, both the total value created in constellations and how this value is distributed among members are contingent on patterns of group organization. Evidence from the global airline industry, which has witnessed the formation of both implicit and explicit constellations, supports this theory.

*Keywords*

Constellations, strategic alliances, networks, cooperative strategy, airline industry

## INTRODUCTION

Many industries are witnessing the formation of firm "constellations" competing against each other for the attraction of new members and for the penetration of their products or services in customer markets (Gomes-Casseres, 1994; 1996). In the computer and microprocessor industries, examples abound where firms pool their resources to sponsor competing technologies and standards (Axelrod, Mitchell, Thomas, Bennett, and Bruderer, 1995; Hwang and Burgers, 1997; Vanhaverbeke and Noorderhaven, 2001). In telecommunications, firms have developed linkages with multiple partners to expand the reach of their networks (Joshi, Kashlak, and Sherman, 1998). Financial exchanges are coalescing into global groups offering distinct contracts and negotiation platforms (Domowitz, 1995). Global airlines, the focus of this study, have also formed groupings competing for international traffic. For instance, a traveler wishing to fly from Kansas City, US, to Gothenburg, Sweden, can use alternative airline groupings offering connections through distinct intermediate hubs. The traveler can use the services of the "Star Alliance"—e.g., United Airlines through Chicago and then Lufthansa through Frankfurt—or, alternatively, the services of the "Oneworld" group—e.g., American Airlines through Dallas and then British Airways through London (Hanlon, 1999; ter Kuile, 1997). All these constellations share similar features: they represent alliances with multiple, rather than simply two firms; their members have a considerable degree of autonomy, in some cases actively switching between groups; and their markets usually reach global dimensions.

Competing constellations have received sparse attention in the literature on interorganizational collaboration.[1] Although there has been a growing interest in interorganizational networks as sources of competitive advantage (Dyer and Singh, 1998; Gulati, Nohria, and Zaheer, 2000), empirical studies have not paid enough attention to the dynamics of

[1] I follow Gomes-Casseres (1996) by adopting the term "constellations" (see also Jones, Hesterly, Fladmoe-Lindquist, and Borgatti, 1998), even though in a previous work he used the term "alliance networks" (Gomes-Casseres, 1994). Constellations have received different names in the literature, such as "strategic blocks" (Nohria and Garcia-Pont, 1991) and "alliance blocks" (Vanhaverbeke and Noorderhaven, 2001). There is also a literature on standard-setting alliances where firm groupings are referred to as "coalitions" (Axelrod, Mitchell, Thomas, Bennett, and Bruderer, 1995; Economides and Flyer, 1997) or "technological communities" (Wade, 1995).

competition in settings involving multiple networks (Gulati, 1998: 310). In other words, empirical research has focused on individual networks in isolation—in general, "ego" networks or the web of alliances surrounding firms (e.g. Dyer and Nobeoka, 2000; Gulati, 1999; McEvily and Zaheer, 1999; Uzzi, 1996)—rather than *competing* networks. Yet, in instances where competition is shifting from firms to constellations, strategic implications can be profound, as a firm's performance may crucially depend on which group it chooses to join (Gomes-Casseres, 1996; Gulati, 1998). Even though past research has empirically analyzed constellations in several industry contexts (Nohria and Garcia-Pont, 1991; Vanhaverbeke and Noorderhaven, 2001; Walker, 1988), the performance implications of constellation membership have not been examined in detail.

In this study, I fill this void in two ways. First, I present a framework to assess *sources* of membership benefits in the context of competing constellations. Building upon Gomes-Casseres (1994; 1996), I distinguish between benefits based on generic attributes of constellations—which I call *constellation-specific* attributes—and benefits based on differential characteristics of firms within the same group—which I call *member-specific* attributes. Constellation-specific attributes include, for instance, the size of the constellation's aggregated customer base in the presence of increasing returns from joint operations and sales. Member-specific attributes, in turn, correspond to the relative *position* of a firm within the group, such as its relative size or the extent to which it has bilateral agreements with other members. While constellation-specific attributes determine the total value generated by the group, member-specific attributes determine how that value is distributed among members. Differential member-specific attributes imply that a firm may obtain higher benefits from membership than other firms even if they belong to the same group.

In addition, I assess the role of group-level *organizational patterns* by studying both explicit and implicit constellations. *Explicit* constellations involve formal, publicly known agreements with a multilateral fashion in that such agreements tend to be broad and general (i.e., applied to all members). *Implicit* constellations, by contrast, are informal groupings "implied" from the structure of bilateral agreements between firms, in such a way that members have relatively more bilateral ties to one another than to firms outside the constellation (Nohria and Garcia-Pont, 1991). A central and novel proposition advanced by this study is that membership in explicit vs. implicit constellations moderates the effect of constellation- vs. member-specific attributes on firm performance. For instance, since explicit constellations involve general, formalized agreements that facilitate coordination and cooperation, the possibility to internalize interfirm externalities is greater than in the case of implicit constellations. Thus, constellation-specific attributes will tend to become relatively more important determinants of firm performance in explicit constellations than in implicit ones. By contrast, the lack of general, overarching agreements in implicit constellations implies that there is more room for individual strategies aimed at increasing both members' access to the resources and customer bases of the group and their compensation for granting access to such resources and markets. Thus, member-specific attributes will tend to become relatively more important determinants of firm performance in implicit constellations than in explicit ones.

The global airline industry provides an appropriate empirical context to study competing constellations. Airlines have aggressively formed alternative groups competing in international markets for both passengers and member airlines through the combination of international routes, joint coordination of operations, and consolidation of marketing tools such as frequent flyer programs (Gomes-Casseres, 1994; Hanlon, 1999; Oum and Yu, 1998). Furthermore, the industry has witnessed the formation of both explicit and implicit constellations. Explicit constellations have emerged especially in the mid 1990s, including (among others) the Star Alliance and the Oneworld group, exemplified before. But there is also evidence that implicit airline constellations have existed before the emergence of explicit groups and in most cases appear to be expanded coalitions with explicit constellations as their core group; for instance, they include firms owned by or holding bilateral agreements with key members of an explicit constellation. This provides an opportunity to compare the effect of membership in explicit vs. implicit constellations. To be sure, an important shortcoming in using the airline industry for the purposes of this study is that regulatory barriers prevent access to global resources and markets through the outright acquisition of, say, domestic airport facilities or carriers (e.g. Hanlon, 1999; Oum and Yu, 1998). Thus, in other contexts hierarchical organization may be a substitute for the use of constellations. But this industry particularity also constitutes a desirable empirical feature, since it allows the researcher to focus on constellation-related choices rather than on choices involving other organizational modes.

The structure of the paper is as follows. In the second section, I present hypotheses about the performance implications of membership in firm constellations. In the third section, I provide background information on the airline industry and the formation of airline constellations. In the fourth section, data and methods are presented. In the fifth session, I discuss the empirical results. I find evidence consistent with the hypothesis that explicit constellations appear to enhance the effect of constellation-specific attributes on firm performance, whereas in implicit constellations the effect of member-specific attributes tends to be more pronounced. Concluding remarks follow.

## CONSTELLATION MEMBERSHIP AND FIRM PERFORMANCE

Constellations are alliances among multiple autonomous firms, such that these groups compete against each other in the same or similar industries for both clients and members.[2] In this section, I distinguish between explicit and implicit constellations, and then present the theoretical framework linking constellation membership to firm performance.

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[2] It is useful to discuss what constellations are *not*. Constellations differ from business groups, such as *keiretsu* in Japan and *chaebols* in Korea. While business groups are in general intra-national organizational forms supported by a common institutional environment—e.g., shared culture or legal regimes (Chang and Hong, 2000; Khanna and Rivkin, 2001)—constellations tend to span different national and institutional borders. Constellations also differ from strategic groups. While those groups are defined as sets of firms defined by mobility barriers to move from one group to another (Caves and Porter, 1977), constellations compete not only for final customers but also for additional members, which can migrate from alternative groups (Gomes-Casseres, 1994; Hwang and Burgers, 1997). Furthermore, differently from strategic groups, constellations may exhibit heterogeneity with respect to the resources brought by members; in some cases, constellations can be comprised of firms belonging to distinct strategic groups (e.g. Nohria and Garcia-Pont, 1991; Walker, 1988). Finally, constellations differ from cartels. Gomes-Casseres (1994: 65) notes that while cartels are stand-alone entities to reduce competition, in most cases there are more than one constellation in an industry competing fiercely against each other.

**Explicit and implicit constellations**

Constellations can be either explicit or implicit.[3] *Explicit* constellations are coalitions involving formal agreements in a *multilateral* fashion: such agreements tend to be general (i.e., applied to all members) and include a broad range of activities. In addition, explicit constellations are publicly known; in most cases, they are even associated with brand names, and their members constitute separate entities and committees to manage the affairs of the group. Examples of explicit constellations are coalitions of international financial exchanges (Domowitz, 1995) and groupings of global airlines emerging especially in the mid 1990s (Hanlon, 1999), which I study in this paper.

*Implicit* constellations, in turn, are informal firm groupings "implied" from the structure of *bilateral* ties between firms.[4] More precisely, an implicit constellation is a cluster of firms showing relatively more ties to one another than to firms outside the group (Nohria and Garcia-Pont, 1991: 109).[5] Previous research has defined constellations implicitly based on the structure of bilateral ties between firms, and empirically examined their boundaries using clustering algorithms. Thus, Nohria and Garcia-Pont (1991) describe implicit constellations in the global auto industry, and Vanhaverbeke and Noorderhaven (2001) reveal clusters of firms in the microprocessor and computer industry devised to introduce the RISC architecture. In some cases, implicit constellations may also be "expanded" versions of explicit constellations in that they may include firms tied to key (though not all) members of the latter.[6]

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[3] This distinction is adapted from Axelrod *et al*., (1995), who focus specifically on standard-setting coalitions (see also Farrell and Saloner, 1988).

[4] Note that bilateral ties in an implicit constellation may be formal, i.e., associated with formal (bilateral) contracts or equity stakes. Implicit constellations are said to be informal because, unlike explicit constellations, there are no general, formal agreements governing the *joint* action of firms beyond what is dictated by their bilateral arrangements.

[5] Such implicit groups can take several forms (Grandori and Soda, 1995; Nohria and Garcia-Pont, 1991; Vanhaverbeke and Noorderhaven, 2001). They can have a "clique"-like structure such as when firm 1 has a marketing agreement with firm 2, which in turn licenses a technology from firm 3, which in turn partially owns firm 1. They can also have a "star"-like structure such as when a firm licenses its technology to several other firms, which in turn have few agreements with suppliers of alternative technologies.

[6] Thus, even though Vanhaverbeke and Noorderhaven (2001) define the boundaries of RISC groups implicitly, they do note that some groups include explicit consortiums such as SPARC (centered on Sun Microsystems) and 88-Open (centered on Motorola).

**Constellations and firm performance**

In any industry, firms face the opportunity to transact with several other firms and form interorganizational networks. Denote the opportunity set of firm as $S$, which is simply a collection of firms indexed by $i = 1, \ldots, N$. Based on their own opportunity sets, firms choose to establish linkages or ties to one another, involving the exchange of resources.[7] In principle, such ties could be governed by any organizational mode from markets to hierarchies. For simplicity, I assume that firm boundaries are fixed. Thus, although linkages can involve partial ownership ties (equity stakes), they cannot be fully hierarchical: each element of $S$ is a separate firm.[8] Such linkages cause a partition of set $S$ into several sub-sets denoted by $C_j \subseteq S, j = 1, \ldots, J$. I call *constellations* only sub-sets with more than one unit; thus, by definition, a firm $i$ not belonging to any constellation is considered to belong to a singleton $\{i\}$. I also suppose that firms can belong to only one constellation at a time, i.e., all sets $C_j$ are disjoint. In the case of implicit constellations, the partition of the set of firms $S$ is inferred from the pattern of bilateral ties among firms; thus, linkages represent either bilateral alliances or equity stakes. In the case of explicit constellations, the partition of set $S$ is straightforward: linkages result from publicly announced coalitions of firms. For the moment, I make no distinction between implicit and explicit constellations, but return to this discussion later on.

Suppose the performance of a firm $i$ belonging to a constellation $C_j$ is given by

(1) $y_i = \pi(\boldsymbol{x}(C_j), \boldsymbol{z}_i(C_j)) + f_i$,

where $\pi(.)$ indicates the benefits that firm $i$ attains by being a member of $C_j$, and $f_i$ denotes firm-specific effects independent of constellation membership. Following Gomes-Casseres (1994), I assume that constellation benefits are influenced by two vectors: $\boldsymbol{x}(C_j)$, representing generic

[7] I simplify the analysis by focusing on horizontal transactions only—i.e., networks in the same industry—in order to avoid a distinction between vertical and horizontal ties. Anecdotal evidence suggests that alliances in the airline industry, which are the focus of this paper, are mostly horizontal, i.e., among carriers (Hanlon, 1999: 240-242). The simultaneous consideration of horizontal and vertical ties, however, can be important in other contexts (see e.g. Lazzarini, Chaddad, and Cook, 2001).

[8] This is a realistic assumption in the airline industry—due to regulatory restrictions to fully acquire foreign carriers—but not necessarily in other industries. I provide more comments on this important issue in the conclusion section of this paper.

attributes of group $C_j$, and $z_i(C_j)$, representing firm *i*'s individual attributes relative to other constellation members (see also Gulati, 1998: 310). I call these characteristics *constellation-specific* and *member-specific* attributes respectively. While constellation-specific attributes (e.g., the size of its aggregated customer base) determine the total value generated by the group, member-specific attributes (e.g., a firm's relative size) determine how that value is distributed among members. Thus, one should expect two sources of interfirm performance differences in the presence of constellations. First, in situations where groups are heterogeneous, distinct constellations with distinct constellation-specific attributes will yield differential membership benefits. Second, in situations where members are heterogeneous, member-specific attributes will induce differential performance for firms belonging to the *same* constellation. In other words, some firms may attain higher membership benefits even if they belong to the same group. Figure 1 schematizes such possible differences.

*<Figure 1 around here>*

**Constellation-specific attributes**

A firm can benefit from joining a constellation when it can capture *positive externalities* emanating from the presence of other firms in the group. Such externalities occur when the benefits that a firm can attain by employing its own resources and targeting its own markets increase when these are articulated, total or partially, with the resources and markets of other firms in the constellation.

Positive externalities can be *scale-driven*. The benefits that customers attain by consuming the products of the constellation may increase with the expected numbers of users, thus characterizing a situation of network externalities (Economides, 1996; Farrell and Saloner, 1985; Katz and Shapiro, 1985; 1994; Rohlfs, 1974). For instance, the attractiveness of a technological standard depends on the extent to which other customers adopt that standard (Arthur, 1989; Axelrod, Mitchell, Thomas, Bennett, and Bruderer, 1995; David, 1985; Majumdar and Venkataraman, 1998; Wade, 1995). This is particularly important when customers face switching costs to pursue alternative products supplied by other firms,[9] thus implying that the attraction of new customers to a particular constellation requires, to a large extent, that their individual suppliers become members. In addition, unit costs may decrease and services may improve due to jointly orchestrated operations. The presence of such increasing returns to scale, although different, is functionally similar to the case of positive network externalities (Tirole, 1988: 409) since it implies that the benefits of a constellation's product increase with the extent of its demand. This discussion implies that the *size of the aggregated customer base* of the group is an important constellation-specific attribute in the presence of scale-driven externalities. Thus:

> *Hypothesis 1. In contexts involving scale-driven externalities, members of a constellation with a large aggregated customer base will outperform members of a constellation with a small aggregated customer base.*

Membership benefits can also be due to *resource-driven* externalities. Some argue that value-enhancing interorganizational relationships are based on the exploitation of resource complementarities, in the sense that the benefits to use a resource increase when it is jointly used with other resources (Grandori and Soda, 1995; Richardson, 1972; Teece, 1992). This suggests that the *resource diversity* of the group may be an important constellation-specific attribute in the presence of resource-driven externalities, for three main reasons. First, customers may have a direct taste for variety (Church and Gandal, 1992).[10] Second, a firm may be able to improve the development or introduction of its own products by capturing spillovers from constellation members assuming specialized and diverse roles (Feldman and Audretsch, 1999; Kogut, 2000; Robertson and Langlois, 1995). For instance, a foreign firm can use local firms' knowledge of domestic markets in several countries to introduce its products. Third, resource diversity implies that intra-group competition will not be strong (Axelrod, Mitchell, Thomas, Bennett, and

[9] For instance, customers may need to invest in learning to understand alternative products or services (e.g., software) and in some cases they are subject to marketing policies increasing the benefits of "loyalty" (e.g., frequent flyer programs) (Klemperer, 1987).

[10] Thus, a constellation offering hardware in conjunction with a large diversity of software will tend to be preferred by customers than a group without such variety.

Bruderer, 1995; Gomes-Casseres, 1994; Lawless and Anderson, 1996). By contrast, firms holding similar resources tend to engage in direct competition since they are able to offer substitute products and thus undercut one another (Chen, 1996; Gimeno and Woo, 1996). This discussion implies:

*Hypothesis 2. In contexts involving resource-driven externalities, members of a constellation with high resource diversity will outperform members of a constellation with low resource diversity.*

There are arguments supporting an opposite prediction, though. Thus, Olk (1997) hypothesizes that groups where firms hold distinct resources will have more difficulty integrating their efforts. Similarly, Kraatz (1998) argues that resource similarity facilitates the formation of strong ties among group members, thereby supporting coordination of joint efforts. As for the effect of resource diversity on competition, Caves and Porter (1977) suggest that tacit collusion is facilitated when firms hold similar, instead of diverse, resources. The reason, the argument goes, is that similar firms are more likely to recognize their strategic interdependence and pursue joint action (see also Gimeno and Woo, 1996; Gnyawali and Madhavan, 2001; Peteraf, 1993).[11]

But the existence of positive externalities will not, by itself, guarantee that firms will be able and even willing to share resources and markets. Although allying firms in constellations preserve their autonomy, arm's-length exchanges will not suffice for the internalization of interfirm externalities (Arrow, 1974). Coordination failure may induce the collective adoption of inferior options (Schelling, 1978).[12] Lack of enough cooperation may also result if members act opportunistically, for instance by free riding on collective investments (Nault and Tyagi, 2001; Olson, 1965) or expropriating other firms' proprietary resources in activities outside the

[11] In this case, the image of a value-enhancing constellation is more akin to the image of a strategic group, where firms hold similar resource profiles. Nohria and Garcia-Pont (1991) differentiate between "pooling" constellations, where most members belong to the same strategic group, and "complementary" constellations, where most members belong to distinct strategic groups and hence hold distinct resource profiles.

[12] The choice of competing technological standards in standard-setting alliances is an example (Economides, 1996; Farrell and Saloner, 1988). Coordination failure is aggravated when, due to bounded rationality, firms do not know all possible actions they could take and their relative payoffs (Foss, 2001)—for instance, which particular resource combinations may lead to superior outcomes—and when they do not know other members' preferences (Farrell and Saloner, 1985).

constellation (Robertson and Langlois, 1995; Teece, 1992; Williamson, 1985). A *dense* web of bilateral ties among firms—i.e., when they are extensively connected with one another—will help to mitigate such failures. Several authors propose that dense networks promote the emergence of shared norms and informal sanctioning mechanisms that enhance cooperation (Coleman, 1988; Granovetter, 1985; Rowley, Behrens, and Krackhardt, 2000; Uzzi, 1996). For instance, if a member of a dense group acts opportunistically, it is likely that in a dense network information about its behavior will be disseminated to other members, which may sever their ties with that firm or apply other types of sanctions (Williamson, 1991: 290-291). By enhancing group cohesion, network density also tends to facilitate joint action and improve communication, consequently reducing the likelihood of coordination failure (Jones, Hesterly, Fladmoe-Lindquist, and Borgatti, 1998). Therefore:

> *Hypothesis 3. Members of a constellation with high density of bilateral ties among firms will outperform members of a constellation with low density of bilateral ties.*

**Member-specific attributes**

While constellation-specific attributes determine the total value generated by the group, member-specific attributes define how that value is divided among members. If firms agree to articulate their resources and pool their customer bases, they will need to define possible ways to do so, and arrange schemes to compensate for the access to resources and markets. Such compensation schemes do not need to be pecuniary, such as in the form of prices for each resource; firms may, for instance, negotiate on the access to certain resources or markets. Using Hirschman's (1970) terminology, I discuss two mechanisms that members can use to articulate resources and markets within the group, and to define the underlying compensation schemes: exit and voice. While *exit* is a bargaining mechanism based on threats to terminate the ongoing interorganizational association, *voice* "involves dialog, persuasion, and sustained organizational effort" (Williamson, 1985: 257). The feasibility and outcome of such mechanisms will be determined by particular member-specific attributes, which in turn will create differential benefits for firms belonging to the same constellation, as I discuss next.

*Exit*

To understand the nature of exit tactics, denote $\Pi(C_j) = \sum_{i \in C_j} \pi(\boldsymbol{x}(C_j), \boldsymbol{z}_i(C_j))$ as the collective value that firms can achieve by being members of constellation $C_j$, and assume for simplicity that members exhaust all possibilities of value creation within the group. Then define the variable

(2) $\Delta_k(C_j) = \Pi(C_j) - \Pi(C_j \backslash \{k\})$,

which is simply the change in the aggregated value of constellation $C_j$ if member $k$ departs the group; in the language of cooperative game theory, $\Delta_k(C_j)$ is the *marginal contribution* of $k$ to coalition $C_j$ (e.g. Osborne and Rubinstein, 1994: 291). If the marginal contribution of firm $k$ is large, then it will be able to threaten its departure from the group unless it obtains higher benefits in the form of compensation schemes. However, other members may object to this threat by arguing that $k$ will also lose if they leave the group. Thus, exit threats will only be effective in a practical sense if a member does not incur substantial losses by forming coalitions with alternative firms. In general, members with large marginal contributions to the constellation and who are able to switch to and benefit from alternative constellations will tend to capture a larger portion of the group's collective value.

In the presence of scale-driven externalities, the *relative size* of a member's customer base will be an important member-specific attribute influencing intra-constellation bargaining, since a member with relatively large customer base will provide a high marginal contribution to other members in the form of network externalities or gains of scale. Thus, large members can threaten to leave the group to partner with larger firms or simply go alone (Economides and Flyer, 1997; Katz and Shapiro, 1985), which would cause a substantial reduction in the level of scale-driven externalities to small members. This asymmetry will grant large members an ability to negotiate better deals within the group. Thus:

*Hypothesis 4. In contexts involving scale-driven externalities, a member with a large customer base relative to the aggregated customer base of its constellation will outperform another constellation member with a relatively small customer base.*

In the presence of resource-driven externalities, in turn, an important member-specific attribute will be the extent to which a member controls *critical resources* within its constellation. Resources are critical when their withdrawal from the set of resources available to the group substantially reduces the benefits from the articulation of the remaining resources. Similarly to a large customer base in the presence of network externalities, members controlling critical resources will have a privileged position in bargaining processes (Harrigan, 1988; Pfeffer and Salancik, 1978). This is because the departure of a member controlling a critical resource will, by definition, sharply reduce the level of interfirm externalities within the group; thus, the marginal contribution of that member will tend to large. Consequently:

> *Hypothesis 5. In contexts involving resource-driven externalities, a member controlling critical resources within its constellation will outperform another constellation member without control of such critical resources.*

Members holding ties to several other firms *outside* the constellation will also be able to benefit from internal bargaining processes. This is because there are sunk costs to form linkages among firms (Kranton and Minehart, 2000), for instance in the form of search costs and investments in exchange interfaces. Thus, it will be relatively less costly for a member to depart from its current constellation and form a new group when that member has existing linkages with alternative firms. In other words, outside ties tend to grant members salient exit options, thereby increasing the credibility of exit threats. Additionally, outside ties tend to be less redundant (Burt, 1992) than ties to existing constellation members. Consequently, holding such ties tends to increase a member's marginal contribution to the constellation, as they represent avenues to obtain external resources and lure new firms to the group. These arguments lead to:

> *Hypothesis 6. A member with bilateral ties to several firms outside its constellation will outperform another constellation member holding no or few bilateral ties to outside firms.*

*Voice*

While exit tactics are based on the relative value that firms add to alternative constellations, voice is based on deliberate actions to obtain group resources and to influence collective decisions. The establishment of extensive bilateral ties to constellation members is likely to be a key mechanism to exercise voice in the group. An obvious reason is that bilateral ties represent direct ways to get access to the resources and markets of particular members. But it is also reasonable to suppose that those ties represent conduits of information and influence beyond their own particular terms (Powell, Koput, and Smith-Doerr, 1996: 120). Notice that, differently from firms, constellations do not have strict hierarchical relations where certain agents are responsible for most decisions. Thus, members that are "more centrally located than others, in the sense that they are directly connected to many members" (Gomes-Casseres, 1996: 56) will have an improved ability to exercise voice. Such members will be more able to control the flow of information within the constellation, lead joint efforts, and influence collective strategies in their favor (Barley, Freeman, and Hybels, 1992; Gnyawali and Madhavan, 2001; Money, 1998).[13] This discussion implies:

*Hypothesis 7. A member holding bilateral ties to several firms belonging to its constellation will outperform another constellation member holding no or few bilateral ties to other members.*

**Group organization: implicit vs. explicit constellations**

I propose that the constellation's organizational form, namely whether it is implicit or explicit, will moderate the effect of constellation- and member-specific attributes on firm performance. Consider first the effect of constellation-specific attributes. The general nature of agreements involving explicit constellations increases the access of firms to the markets and resources of the whole group, which in implicit constellations is defined solely on a bilateral basis. This process is facilitated by the adoption of common, standardized exchange procedures in explicit groups. Standardization creates compatibility across members' production and marketing systems, thereby expanding the possibility to exploit complementarities (Schilling and Steensma, 2001; Thompson, 1967). In addition, the process of creating and managing formal, general agreements also represents an opportunity for multilateral communication and negotiation, which reduces the likelihood that the group will be trapped into inferior collective

[13] Similar arguments support the idea that central individuals will have higher influence in the process of decision-making within firms (e.g. Brass and Burkhardt, 1992; Krackhardt, 1990).

strategies (Farrell and Saloner, 1988; Schelling, 1978). Explicit constellations may be associated with formal boards and committees, which not only act as control devices, but also enhance the achievement of collective agreements. Once established, formal agreements can also curb opportunistic behavior by establishing clauses specifying the role and obligations of members (Poppo and Zenger, forthcoming).[14] Therefore, by facilitating coordination and cooperation, explicit constellations tend to augment the internalization of interfirm externalities borne by constellation-specific attributes.

Furthermore, the fact that explicit constellations are publicly known can influence expectations about the prospects of the group. Thus, the market penetration of a constellation's products in the presence of network externalities is largely dependent on whether customers expect the constellation to thrive or not (Economides, 1996; Katz and Shapiro, 1985). Promotion tactics and even brand names attached to the constellation are helpful precisely because they can help to influence such expectations (Katz and Shapiro, 1994: 107). In a similar vein, Human and Provan (2000) argue that the formalization of interfirm networks brings legitimization and visibility to the group, which helps to attract not only new customers but also supporting actors such as suppliers and investors. This tends to increase the level of externalities that firms can internalize by collaborating. Collectively, the arguments above suggest that the effect of constellation-attributes will be more pronounced in explicit than implicit constellations. Thus:

*Hypothesis 8. Constellation-specific attributes will contribute more to explaining interfirm performance differences in explicit constellations than in implicit ones.*

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[14] One might argue that informal sanctioning mechanisms brought by network density, which is a constellation-specific attribute, may actually *substitute* for explicit agreements in promoting cooperation (e.g. Granovetter, 1985). Contrary to this view, I argue that explicit constellations increase the effectiveness of such informal sanctioning mechanisms. First, because communication is improved and hence information about opportunistic behavior is more easily disseminated in the network. Second, because formal organization increases the likelihood that "boycotts" against deviants will be carried out (see Greif, Milgrom, and Weingast, 1994). Due to improved member participation, offended parties will have more leeway to convince other members to apply sanctions. As a result of these sanctions, deviants will be more strongly penalized in dense rather than sparse networks because defection will trigger the termination of several bilateral ties with constellation members. Notice that such ties may involve activities beyond those included in the constellation's explicit agreement.

In the case of member-specific attributes, this effect is reversed. The benefits that a firm can attain by being part of an implicit constellation will be largely dependent on its position in the group. Since in implicit constellations there are no general terms guiding joint action, there is more room for exit and voice tactics to define collective strategies and compensation schemes. For instance, large and central firms tend to assume leading roles in implicit constellations, since they are likely to have a higher ability to form and manage multiple ties. In addition, the absence of general agreements in implicit constellations implies that a firm must establish direct ties to other members to increase its access to their resources and markets. Otherwise, that firm will only attain indirect membership benefits through its ties to central members, which will act as "intermediaries" in the transfer of interfirm externalities.

By contrast, in explicit constellations the action shifts, albeit partially, from bilateral to multilateral negotiations. As agreements become more comprehensive and general, bilateral agreements become less instrumental in delivering direct access to the resources and markets of the whole group. Increased participation in the process of decision making—for instance, through committees or boards—tend to increase members' voice over collective strategies and redistribution rules. In addition, since the formalization of interfirm alliances demands idiosyncratic expenses to multilaterally negotiate agreements and create common exchange procedures, the efficacy of exit tactics diminishes. Other things being equal, firms will lose more value if they defect from an explicit than an implicit constellation. This discussion suggests that in explicit constellations the effect of member-specific attributes will tend to be attenuated relative to implicit constellations, thereby leading to:

*Hypothesis 9. Member-specific attributes will contribute more to explaining interfirm performance differences in implicit constellations than in explicit ones.*

## CONSTELLATIONS IN THE GLOBAL AIRLINE INDUSTRY

### Cooperation and competition in the airline industry

Since the deregulation of the U.S. industry and the increasing privatization of carriers in Europe and East Asia, competition between airline companies has reached a global status due to the desire to expand route networks internationally (Morrison and Winston, 1995; Pustay, 1992; Taneja, 1988). However, existing regulatory policies that constrain the acquisition and use of foreign resources pose major challenges to international air travel. Although there are instances of companies holding equity stakes in international carriers, most governments disallow complete foreign ownership of domestic airlines and airport facilities (Hanlon, 1999; Pustay, 1992). The international air traffic is also heavily regulated. Since the 1944 Chicago Convention on International Civil Aviation, the permission to carry out international traffic has been established by agreements between countries mainly on a bilateral basis (Holloway, 1998; Oum and Yu, 1998; Pustay, 1992; Taneja, 1988). In addition, it is rare that an airline is granted permission to service routes within foreign countries, which is called "cabotage" (Hanlon, 1999; Holloway, 1998). In this context, alliances become a fundamental recourse for airlines to expand internationally (Oum and Yu, 1998; Park and Zhang, 2000; Park and Martin, 2001). Reflecting this fact, the industry has witnessed the formation of several alliances between carriers, especially during the 1990s. Estimates indicate that in 2000 more than 80% of airline companies engaged in some form of alliance (Baker, 2001).

The first airline alliances were purely *bilateral*, involving agreements between two carriers only. The most common type of bilateral alliance is the so-called *codesharing* agreement, by which two carriers combine routes as a single composite product to customers. Usually one firm (the "marketing carrier") sets the price and sells the flight, while the other firm (the "operating carrier") becomes responsible for the connecting routes (Bamberger, Carlton, and Neumann, 2001).[15] Codesharing agreements usually involve substantial efforts to jointly coordinate the flow of passengers and baggage, as well as sharing of airport resources such as gates, lounges,

[15] Partners receiving antitrust immunity from the U.S. Department of Transportation can also jointly price certain routes involving U.S. cities (Brueckner and Whalen, 2000).

check-in infrastructure, and ground personnel (Chen and Ross, 2000).[16] Carriers also engage in *marketing* agreements such as the establishment of joint frequent flyer programs (FFP) and combined promotion efforts.

*Explicit* airline constellations, moving beyond purely bilateral deals, have emerged especially in the 1990s. Most explicit constellations involve full marketing cooperation with respect to FFPs and promotions, besides joint access to airport facilities (such as lounges) controlled by individual members. Some groups also offer comprehensive codesharing agreements involving several routes instead of bilateral agreements comprising few routes (Oum and Yu, 1998). Thus, agreements tend to have a multilateral fashion, in that they are applicable to all members and broad in nature.[17] Estimates indicate that the five existing explicit airline constellations in 2001—Star Alliance (including United Airlines, Lufthansa and SAS), Oneworld (including American Airlines and British Airways), SkyTeam (including Delta and Air France), Northwest/KLM (unofficially labeled "Wings"), and Qualiflyer (including Swissair and other European carriers)—contributed to almost 60% of the global air traffic, representing 203.3 billion dollars in revenues (Baker, 2001). (I present more details on the evolution and composition of these groups later.) But there is evidence of the existence of *implicit* constellations prior to the emergence of most explicit airline groupings, corresponding to firm clusters based on extensive bilateral agreements (Whitaker, 1996). As I discuss next, some implicit constellations also appear to be expanded coalitions with key (though not all) members of explicit constellations as their core group.

**Capturing externalities from airline constellations**

[16] A related type of alliance is the *block space* agreement, through which a marketing carrier buys a block of seats from an operating carrier and then sells those seats to its customers (Hanlon, 1999). Block space agreements can also be used as a mechanism to transfer payments in codesharing alliances (Bamberger, Carlton, and Neumann, 2001).

[17] Even though some contractual features of those groups are truly multilateral (such as FFPs), an interviewed airline executive considers that, during the period covered in this study, most deals within explicit constellations still tended to be negotiated on a bilateral basis. But there is a perception that such agreements are becoming more and more comprehensive. Thus, the results presented here should be properly taken as conservative estimates of the impact of explicit groups.

Evidence suggests that there are both scale- and resource-driven externalities emanating from interorganizational linkages in the airline industry. As discussed before, scale-driven externalities result mainly from demand aggregation and gains from scale generated by an increase in the size of the constellation. When routes are jointly coordinated, as in the case of codesharing alliances, the quality of customer service will tend to increase since it resembles a "single-carrier" service with respect to check-in and baggage handling (Bamberger, Carlton, and Neumann, 2001; Brueckner and Whalen, 2000; Youssef and Hansen, 1994). Joint operations and marketing activities are also expected to reduce unit costs due to economies of scale (Bamberger, Carlton, and Neumann, 2001; Oum and Yu, 1998; Park and Zhang, 2000). As a result, improved service and lower costs will tend to increase demand for such coordinated services.[18]

FFPs magnify the extent of scale-driven externalities because of the costs they impose to customers to switch to alternative airlines. Since FFPs reward customers who purchase tickets from the same carrier, "customers who switch between different companies are penalized relative to those who remain with a single firm" (Klemperer, 1987: 376). Thus, by establishing joint FFPs, airlines can benefit from the captive demand of other firms. FFPs can also be considered a particular type of standard since, once multiple carriers form a large network, customers will have increasing benefits if they continue using a particular FFP instead of programs offered by competitors. As an executive from an airline member of a certain explicit constellation once affirmed, the combined FFP "is the glue to hold the alliance together" (quoted in Hanlon, 1999: 57).

[18] Even if allying carriers monopolize connections comprising a route, prices may be lower than in the case of independent sale and pricing of such connections, which will also contribute to an increase in demand. This is because when a single airline sets the price for the total route or partners jointly do so (in cases where they are granted antitrust immunity), "double marginalization" is eliminated. The so-called Cournot double marginalization problem occurs when a monopolist pricing a downstream product introduces a mark-up over the mark-up of the monopolist offering a complementary, upstream product (see e.g. Economides and Salop, 1992). The reduction in prices from the elimination of double marginalization when one firm or both firms price the *whole* nexus of products is expected to prompt demand. Empirical evidence in the airline industry is corroborative (Bamberger, Carlton, and Neumann, 2001; Brueckner and Whalen, 2000).

Resource-driven externalities also appear to be important in the context of the global airline industry. Given the recognition that "network strategy is the foundation upon which everything else in an airline is built" (Holloway, 1998: 280), access to the air transport infrastructure in foreign cities—especially airport facilities—is considered a fundamental resource for global airlines (Hanlon, 1999; Park and Martin, 2001). This is because the articulation of resources owned by individual carriers allows for the exploitation of complementarities between routes. For instance, in a one-stop flight connecting two cities, "the two legs of the journey are two complementary components of the complete flight" (Encaoua, Moreaux, and Perrot, 1996: 703). To create this composite route, two or more carriers will need to coordinate the joint use of their local resources in origin, destination, and stop points. Since global carriers face regulatory restrictions to invest in domestic feeders within foreign countries, they must ally with other airlines controlling local facilities, which in turn act as local hubs and thus help to bring local customers to the global network (Hanlon, 1999; Youssef and Hansen, 1994). In this context, the resource-driven benefits of constellations may also be dependent on the extent to which some members specialize and develop competencies associated with small, local markets acting as feeders, while other members specialize in longer, international connections covering large markets (Bailey and Williams, 1988; Clougherty, 2002; Holloway, 1998).[19]

## DATA AND METHODS

### Data

This study uses information on the operations of 75 global airlines as well as their alliances and patterns of membership in constellations between 1995 and 2000. The carriers in the sample represent about 81% of the total world passenger traffic in 2000, and 54 distinct countries (Table

[19] Unlike scale-driven externalities, which presuppose gains from an increase in the size of the network and its customer base, resource-driven externalities are based on gains from *traffic density* (Brueckner and Spiller, 1994; Caves, Christensen, and Tretheway, 1984), which allow airlines to schedule flights from or to different points and thus offer more options to customers. To be sure, traffic density also enhances the flow of passengers and creates economies—e.g., more efficient utilization of aircraft and crew—which are akin to scale-driven externalities. However, traffic density presupposes the combination of qualitatively complementary routes, which are largely dependent on the resources available in the network rather than necessarily its size.

1).[20] The data come from multiple sources. Carriers' operational information, such as traffic and capacity, is obtained from the *World Air Transport Statistics* compiled by the International Air Transport Association (IATA). Data on airline alliances and the evolution of constellations are taken from several issues of the magazine *Airline Business*, which conducts annual surveys on the alliance activity of the industry. Since it is based on annual surveys, an advantage of this alliance database is that it provides a picture of alliances that were actually in place in a particular year.[21] I also obtain information on equity stakes among carriers from several issues of *Airline Business*. Finally, I collect information on international routes serviced by carriers from the International Civil Aviation Organization's (ICAO) digest of statistics *Traffic by Flight Stage*.

*<Table 1 around here>*

The database involves information on individual carriers observed through time; thus, the data have a panel structure. Besides the fact that alliances in the airline industry are prevalent and there is substantial heterogeneity in terms of routes serviced, countries of origin, dominance of local resources (such as airport facilities), performance, and composition of constellations, the database has several other attractive features to test the hypotheses presented above. First, airlines are in general focused businesses (Gimeno, 1999; Miller and Chen, 1994). This tends to reduce error in the analysis of the relationship between alliances and overall firm performance, which in diversified companies can be affected by unobserved variables due to other business lines. Second, although there is heterogeneity in terms of the markets and resources of

[20] The estimate of world passenger traffic used here is taken from Baker (2001). Individually, these databases contain information on more than 75 carriers, but I still had to reduce the sample size due to missing data on certain variables of interest for certain carriers. Whenever feasible, I supplemented missing data with information obtained through Nexis-Lexis. I excluded carriers that, over the *whole* period, were fully owned by another airline carrier. However, some mergers and full acquisitions occurred especially in the last year. Thus, in 2000 TWA was acquired by American Airlines, Canadian Airlines by Air Canada, and European carriers AOM and Air Liberte (jointly with Air Littoral) merged.

[21] I disregard agreements that were pending in a given year, and focus on passenger agreements only (i.e., exclusive cargo agreements are not included in the sample.) Sometimes, a survey at year $t$ indicates that an alliance resumed in year $t - n$, but there is no reference to that alliance in the $t - n$ survey. Unless the latter indicates that the alliance is pending at $t - n$, I consider that the alliance was already in place in that period. I also ignore ties exclusively based on common computer reservation systems, which are considered to be regional in nature (Hanlon, 1999; Pustay, 1992).

individual airlines, air transportation technology is fairly standardized, which facilitates cross-comparisons (Oum and Yu, 1998; Park and Martin, 2001). Third, in the period under analysis several explicit constellations were formed and the pattern of interfirm linkages suggests several implicit groups, which allows for their comparative assessment.

**Constellation membership: implicit vs. explicit groups**

Following previous work (Nohria and Garcia-Pont, 1991; Vanhaverbeke and Noorderhaven, 2001; Walker, 1988), I adopt a clustering approach to demarcating the boundaries of implicit constellations, based on the matrix of bilateral ties among carriers in the sample. I employ a clustering algorithm based on *tabu search* optimization (Glover, 1989), which is available in the software *UCINET 5.0* (Borgatti, Everett, and Freeman, 1999). An advantage of this algorithm is that it finds groups given a certain pre-specified number of partitions, independent of the clustering configurations found with fewer partitions. Thus, it does not present the critical shortcoming of conventional hierarchical clustering algorithms, where a partition "made at one of the early stages of the analysis cannot be undone at a later stage" (Wasserman and Faust, 1994: 385). This is a restriction imposed by hierarchical clustering algorithms, rather than necessarily a feature of the data.[22] Basically, the clustering algorithm maximizes a "fit" function based on the average "proximity" of group members defined in terms of the existence of bilateral ties to one another, given a pre-specified number of groups or partitions. Thus, the algorithm has a clear rule for optimizing the composition of groups, which is somewhat obscure in other clustering methods (Lawless and Anderson, 1996).

To create a matrix of interfirm linkages, I simply consider that there is a linkage between two firms (coded 1) when they have either a bilateral alliance or an ownership relation (i.e., when at least one of the carriers has an equity stake in the other carrier). Otherwise, I consider that there is no linkage (coded 0).[23] Such a matrix is constructed for every year in the sample. Prior to the

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[22] The hierarchical clustering algorithm *CONCOR* has still another major drawback: it promotes successive splits of existing sets in exactly two new subsets. Again, such binary partitions may not be a feature of the data in hand (Wasserman and Faust, 1994: 380).

[23] Alternatively, I could consider the "strength" of a tie between two carriers based on the nature of their relationship; for instance, I could attach a higher score for linkages involving an ownership relation (e.g. Nohria and

application of the optimization algorithm, I first perform a visual inspection of the overall network, to find carriers that either do not have ties to the carriers in the sample or that have only isolated, pair-wise ties. I drop such carriers from the sample prior to the clustering analysis (e.g. Vanhaverbeke and Noorderhaven, 2001). Then I run the algorithm a couple of times to find out carriers that are classified into particular groups, but that do not show ties to any member of such groups. Since this suggests that such actors do not have a clear pattern of membership, I also drop them from the sample prior to the final analysis. Although tabu search greatly increases the likelihood that a global maximum will be found (Lawless and Anderson, 1996), the procedure may in some cases get trapped into a local maximum or stop before superior solutions are found. In an attempt to avoid this, I run the algorithm five times and choose the clustering configuration that yields the highest value of the "fit" function.[24]

Any clustering algorithm, however, has an important drawback: there is a lot of subjectivity in choosing the "ideal" number of partitions (Barney and Hoskisson, 1990; Wasserman and Faust, 1994). In the present study, I choose 5 partitions for two main reasons. First, in the last year of the sample (2000), there were 5 explicit constellations in place. Thus, if I follow the conjecture, discussed earlier, that implicit constellations may be either precursors of explicit groups or "expanded" versions of such groups when they are in place, then it makes sense to find a clustering pattern that has some correspondence to the eventual configuration of explicit constellations. Second, transatlantic routes between Europe and the United States are considered to be a key target for global airline alliances.[25] Thus, it is natural to assume that key competing U.S. carriers will be central players in each group. In my sample, four U.S. carriers can be considered key international players: American Airlines, Delta, Northwest Airlines, and United

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Garcia-Pont, 1991; Rowley, Behrens, and Krackhardt, 2000). In the present context, this procedure is problematic since in some cases carriers have equity stakes in other firms but there is no publicly announced bilateral alliance involving, for instance, codesharing. To avoid unjustified assumptions guiding differential coding schemes, I opt for the simple criterion described before.

[24] In some cases, even after eliminating some carriers prior to the actual optimization runs, the procedure groups together some carriers that do not have direct ties, or that show only pair-wise, isolated ties. I again drop such carriers from the composition of the final groups.

[25] As mentioned by an airline executive, "some 80 per cent of the benefits from any of the global alliances come on the transatlantic" (quoted in Odell and Spiegel, 2002).

Airlines, thus suggesting at least 4 constellations.[26] Adding an apparent cluster of European carriers led by Swissair results in 5 groupings.

The demarcation of the boundaries of explicit constellations, by contrast, is straightforward: it is simply based on public announcements of carriers' membership in constellations, as well as (if this is the case) their departure from those groups, as published in the magazine *Airline Business* and other sources obtained through Nexis-Lexis.[27]

**Dependent variable**

I employ carriers' passenger *load factor* as a performance measure, which serves as the dependent variable in this study. The load factor is a measure of aircraft capacity utilization. More precisely, it is the ratio of carrier *i*'s total traffic, measured in revenue passenger kilometers (RPK), to its overall traffic capacity, measured in available seat kilometers (ASK), at year *t* (%). This corresponds to the variable $LoadFactor_{it}$. The main advantage of this measure is that it is a simple and standard way in the industry to compare the performance of airlines. Its main disadvantage is that it ignores the role of non-passenger sources of revenue and operational inputs besides aircraft capacity, such as labor (Schefczyk, 1993). Previous research has found, however, that a carrier's load factor is significantly related to its financial performance (e.g. Behn and Riley Jr., 1999; Morrison and Winston, 1995).

**Independent variables**

*Constellation-specific attributes*

*Size*. I measure the size of the aggregated customer base of the constellation using the variable $TotTraffic_t(C_j)$, which corresponds to the total scheduled passenger traffic (sum of individual billion RPKs) of constellation $C_j$ at year *t*. To avoid a spurious correlation between

[26] The other carriers in the sample are less significant international players. Alaska Airlines, America West, and US Airways are mostly domestic carriers. TWA was acquired by American Airlines in 2000. Continental Airlines, in turn, has an extensive agreement with Northwest Airlines.

[27] I assume that a carrier is a member of an explicit constellation in a given year if it announced its association to the group in the first half of that year, i.e., between January and June. If an explicit constellation is dissolved in a given year, I assume that the group is in place in that year if the termination occurs in the second half of that year.

this variable and the size of a carrier's *individual* customer base, for each carrier I exclude from this variable the carrier's total passenger traffic.[28]

*Resource diversity*. Based on the discussion in the previous section, an important resource in the airline industry is the infrastructure in foreign cities, since there are regulatory barriers for carriers to establish international hubs. Thus, the constellation will exhibit diversity regarding this resource when members are positioned in distant cities/hubs, which expands the possibilities for connections. By contrast, similar or proximate hubs will more likely be substitutes than complements. Based on this idea, I define the variable $d_{ik}$ as the distance (in 1,000 kilometers) between the cities where the main hubs of carriers $i$ and $k \in C_j$, are located. The main hub of a carrier is defined as the city which, for that particular carrier, shows the highest number of departing connections to other cities as evidenced by the *Traffic by Flight Stage* database.[29] The measure of diversity within constellation $C_j$ with respect to the availability of distinct cities/hubs at year $t$, labeled $DiversCity_t(C_j)$, is equal to $[\sum_i \sum_{k<i} d_{ik}]/[\frac{1}{2} m_t(C_j)(m_t(C_j) - 1)]$, where $m_t(C_j)$ is the number of members of constellation $C_j$ at year $t$. This measure gives the average distance between the main hubs of all carrier-pairs within the constellation. If all carriers belong to different but close countries, the value of $DiversCity_t(C_j)$ is likely to be small. Its value is largest when carriers belong to different and distant countries, i.e., when their headquarters are "scattered" around the globe.

The discussion in the previous section also suggests that resource diversity in airline constellations depends on whether some members specialize in small, domestic markets, while other members specialize in large markets with a broad range of international routes. Clougherty (2002) shows that a large domestic network can improve a carrier's competitive position in international markets. Based on this idea, I also assess diversity based on the *international*

[28] This variable, as well as the other constellation-related variables discussed below, is measured twice considering the composition of a carrier's constellation as defined both implicitly and explicitly.
[29] For few carriers, the classification of certain cities as main hubs, as defined before, varies from period to period—possibly because those carriers operate through multiple international hubs. For such carriers, I consider the hub that most frequently presented the highest number of departing connections over all the years in the sample. However, this choice should not strongly affect the measure because multiple hubs are in the same country and hence their distance to other cities in different countries tends to be similar.

*positioning* of constellation members defined as the percentage of their total passenger traffic (RPK) at year $t$ coming from international traffic. Thus, the variable $DiversIntPosit(C_j)$ measures the standard deviation of individual carriers' international positioning for members of constellation $C_j$ at year $t$. A high value of this variable indicates that the constellation has a mix of carriers specializing in international and domestic routes.

*Density of bilateral ties*. The variable $Density_t(C_j)$ measures the density of the network of bilateral ties within constellation $j$ at year $t$, which is simply the observed number of existing ties relative to the total possible number of ties between members.[30]

*Member-specific attributes*

*Relative size*. A carrier's relative size within its constellation is measured by the variable $RelCapacity_{it}(C_j)$, which refers to the ratio of carrier $i$'s passenger available seat capacity (ASK) to the total capacity of its constellation, $C_j$, at year $t$.

*Dominance of critical resources*. As previously discussed, foreign hubs are fundamental resources in global airline constellations, and they will be relatively more critical when they receive traffic from several other hubs. Consider, for instance, the hypothetical hub-and-spoke route network depicted in Figure 2. Hub $H_2$ is very important in this network because it receives traffic directly from three other hubs ($H_1$, $H_3$ and $H_4$) and indirectly through their spokes. Intuitively, this is because hub $H_2$ is "in between" those other points and thus is expected to receive a large fraction of the overall flow of passengers coming from and going to other hubs and spokes. This suggests the use of the standardized *betweenness centrality* measure in network analysis (Freeman, 1979; Wasserman and Faust, 1994) to indicate the importance of each city in receiving traffic from the constellation's route network.[31] Cities with large betweenness centrality scores are likely to be central hubs in the international route network, whereas cities

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[30] Formally, suppose that a constellation $C_j$ with $m_t(C_j)$ members shows $b_t(C_j)$ pair-wise ties at year $t$. Then $Density(C_j)$ will be equal to $b_t(C_j)/[½m_t(C_j)(m_t(C_j)-1)]$ (Wasserman and Faust, 1994).

[31] Suppose $g_{uv}$ is the number of geodesics (shortest paths) linking two cites $u$ and $v$, and $g_{uv}(k)$ the number of geodesics linking the two cities that contain city $k$. Then the betweenness centrality measure of city $k$ is defined by $\sum_{v<u} g_{uv}(k)g_{uv}$ where $k \neq u, v$. The *standardized* measure corresponds to this value divided by the number of all possible city-pairs not including city $k$, i.e., $½(c-1)(c-2)$, where $c$ is the total number of cities.

with low scores are likely to be either local hubs or spokes. In the network of Figure 2, $H_2$ has indeed the largest standardized score (70.91), followed by $H_1$ (61.82), and then $H_3$ and $H_4$ (34.55). The betweenness centrality of the other nodes (spokes) is zero. Within this perspective, using information from the *Traffic by Flight Stage* database, for each year I first construct a matrix of global city-pairs where each entry is coded 1 if there is a flight departing from a city (row) to another city (column) offered by at least one member of a particular constellation $C_j$ at year $t$. Based on this matrix, I use the software *UCINET 5.0* (Borgatti, Everett, and Freeman, 1999) to compute the standardized betweenness centrality score of each city $k$, denoted $w_{kt}(C_j)$.

*<Figure 2 around here>*

The next step is to measure how carriers dominate such critical hubs. Still using ICAO's *On-Flight Origin and Destination* statistics, I compute for each city-pair $k$ the number of carrier-routes departing from that city and offered by all carriers in the industry, belonging or not to the constellation, at year $t$.[32] I then define $p_{ikt}$ as the proportion of all carrier-routes from city $k$ serviced by carrier $i$ at year $t$. This provides an indication of the extent to which a carrier dominates the traffic involving a particular city. The final measure, denoted as $DomHub_{it}(C_j)$, is equal to the sum $\sum_k w_{kt}(C_j)p_{ikt}$, where $k$ indexes all cities belonging to the route network of the constellation. Intuitively, this measure indicates a carrier's dominance of the traffic (in terms of route counts) involving cities in the network of the constellation weighted by the relative importance or criticality of those cities in terms of traffic aggregation.[33]

*Bilateral ties to firms outside the constellation*. The variable $OutsideTie_{it}(C_j)$ is the proportion of carrier $i$'s total bilateral ties (i.e., to any firm in the sample) that are to carriers *not*

[32] For instance, if a city is connected to only one city in the route network, and the connection is serviced by two carriers, then the number of carrier-routes involving that city is 2.

[33] Ideally, one should use information on the individual *traffic* of city-pair routes to compute this measure. However, the *Traffic by Flight Stage* database does not contain traffic information for all routes surveyed. Instead of disregarding routes for which data on traffic are missing, which would for some carriers discard information on their entire route networks, I opt to use instead a rough assessment of carriers' relative traffic based on route counts, as described before. Despite its limitations, the use of the *Traffic by Flight Stage* database is not without precedent in the airline industry literature (e.g. Clougherty, 2002; Park and Zhang, 2000).

belonging to its constellation, $C_j$, at year *t*. Thus, it measures the extent to which carrier *i* has external options in terms of relationships with firms outside its constellation.

*Bilateral ties to other constellation members*. The variable $InsideTie_{it}(C_j)$ is the proportion of members of constellation $C_j$ to which carrier $i \in C_j$ has bilateral ties at *t*.

*Control variables*

*Carrier- specific attributes*. As usual in studies assessing determinants of firm performance, I employ several controls related to firm size. $Capacity_{it}$, $Employees_{it}$, and $Routes_{it}$ measure respectively carrier *i*'s passenger seat capacity (billion ASK), number of employees (in thousands), and number of serviced international routes (in thousands, according to the *Traffic by Flight Stage* database) at year *t*. Since the existence of cargo activity has been shown to affect a carrier's performance (Oum and Yu, 1998), I also include the variable $Cargo_{it}$, which measures the ratio of carrier *i*'s cargo flights (measured in billion RTK, revenue tonne kilometers) to its number of employees (in thousands) at year *t*. Finally, to control for possible differences in terms of carriers' experience in the industry, I employ the variable $Age_{it}$, which indicates the time elapsed, at *t*, since the carrier's founding.

*"Ego" network*. Variables related to constellation membership are likely to be correlated with the structure of carriers' "ego" networks, defined as the set of firms to which they are *directly* tied. Failure to control for this fact may generate a spurious correlation between constellation-related variables and performance: carriers may benefit from their own network of direct ties rather than from membership in constellations. Thus, I include the variables $EgoTies_{it}$ and $EgoTraffic_{it}$, which measure respectively carrier *i*'s total number of bilateral ties to other firms in the sample, and the sum of the individual traffic (billion RPKs) of those firms to which carrier *i* is directly tied at year *t*.

*Multimarket contact*. Multimarket contact facilitates tacit collusion because a particular firm can retaliate against another firm's competitive hostility in a certain market through an escalation of competition in other shared markets (Bernheim and Whinston, 1990; Karnani and Wernerfelt, 1985). In the present study, controlling for multimarket contact is important because, as shown by Gimeno and Woo (1996), it may be correlated with resource similarity. Thus, failure to control for multimarket contact may bias the analysis of the impact on a firm's resource profile and performance.[34] Studies of multimarket contact in the airline industry have considered city-pair routes as the relevant markets or points of contact. Thus, using the *Traffic by Flight Stage* database, I first compute the variable $r_{ikt}$ representing the number of international city-pair routes jointly serviced by two carriers $i$ and $k$ ($i \neq k$) at year $t$. For a certain carrier $i$ belonging to a constellation $C_j$, and considering all other constellation members $k \in C_j$, I then compute the value $(\sum_k r_{ikt})/(m_t(C_j) - 1)$, where $m_t(C_j)$ is the number of members of constellation $C_j$ at year $t$. The resulting measure, denoted $Contact_{it}(C_j)$, represents the average number of international route contacts between carrier $i$ and other members of its constellations. Since this is essentially a member-specific variable, I also create a group-level measure called $GrContact_t(C_j)$, which is simply the mean of $Contact_{it}(C_j)$ for all $i \in C_j$, i.e., the average number of international route contacts among all group members.

*Country-specific controls*. I employ a set of country-specific variables to control for time-varying effects related to carriers' domestic markets, which are likely to affect their performance: the country's per capita GDP ($GDPCap_{it}$, 1,000 US$), GDP percent growth ($GDPGrow_{it}$), and population ($Pop_{it}$, billion inhabitants). This information is obtained from the World Bank's *World Development Indicators* database.

*Year-specific controls*. Finally, I create a set of dummy variables representing each year in the observation window, denoted as $Year(t)$, in order to control for temporal effects such as variations in economic and regulatory conditions over time, as well as trends in the pattern of interfirm alliances.

[34] Namely, even if a firm controls non-critical resources within the group, it may not suffer intense competition from other members if they compete in several markets and, for this reason, tacitly collude. Although multimarket contact has been largely studied in terms of pricing decisions (e.g. Evans and Kessides, 1994; Gimeno and Woo, 1996), it may also influence the extent to which individual demand or capacity is affected by competitive rivalry (Gimeno, 1999), which in turn may affect the performance measure used in this study (load factor).

Table 2 lists all the variables described above. Since separate regressions are run for explicit and implicit constellations, summary statistics of those variables are presented separately for each case—respectively, Tables 3 and 4.[35]

*<Tables 2, 3 and 4 around here>*

**Method**

To estimate equation (1), I use a linear specification for the function mapping constellation- ($\boldsymbol{x}(C_j)$) and member-specific attributes ($\boldsymbol{z}_i(C_j)$) onto firm performance ($y_{it}$): $\pi(\boldsymbol{x}(C_j), \boldsymbol{z}_i(C_j)) = \boldsymbol{x}_t(C_j)\boldsymbol{\beta} + \boldsymbol{z}_{it}(C_j)\boldsymbol{\gamma}$. I assume additionally that the carrier-specific term $f_i$ takes the form $f_i = \boldsymbol{w}_{it}\boldsymbol{\delta} + \tau_t + e_{it}$, where $\boldsymbol{w}_{it}$ is a vector of firm-specific control variables, $\tau_t$ denotes year-specific effects, and $e_{it}$ is an error term. Following Finkel's (1995) recommendation, I also add the lagged value of the performance variable, $y_{it-1}$, as an explanatory term to control for adjustment processes in panel settings.[36] Thus, (1) is rewritten as

(3) $y_{it} = \boldsymbol{x}_t(C_j)\boldsymbol{\beta} + \boldsymbol{z}_{it}(C_j)\boldsymbol{\gamma} + \boldsymbol{w}_{it}\boldsymbol{\delta} + \tau_t + \lambda y_{it-1} + e_{it}$.

This equation is estimated twice: in the first regression, $C_j$ corresponds to carrier $i$'s *implicit* group; in the second, it corresponds to carrier $i$'s explicit group (if any). With respect to the error term $e_{it}$, I initially employ a standard random-effects specification by assuming that $e_{it} = \alpha_i + \varepsilon_{it}$ where $\alpha_i$ is a time-invariant, firm-specific term, and $\varepsilon_{it}$ is a time-varying error term, and that both terms are normally distributed and uncorrelated with the independent variables. The model is estimated via generalized least squares (GLS).

However, estimating the model above has two sorts of problems. First, not all firms in the sample belong to an explicit constellation. Since firms self-select whether they will join an explicit constellation or not, unobserved firm-specific factors (such as competencies to form and formalize multilateral agreements) may cause systematic performance differences conditional on a firm having chosen a particular explicit constellation, and bias the estimates as a result. To test

[35] The table reveals no critical problem of multicollinearity involving the key (constellation-related) explanatory variables. $Capacity_{it}$ and $Employees_{it}$ are highly correlated but they are essentially controls.
[36] This is particularly important here since the dependent variable here is the load factor, which crucially depends on how carriers adjust their seat capacity to changing traffic conditions.

for the presence of selectivity bias, I employ the now-standard Heckman (1979) two-stage approach. In the first stage, considering all firms in the sample, I run a Probit model where the dependent variable ($Expl_{it}$) is binary and codes whether the firm belongs to any explicit constellation at $t$ or not. As explanatory variables, I use all control variables described before (except for the multimarket contact controls, which are not observed for non-members of explicit constellations) and a set of instrumental variables. The first instrument, $Expl_{it\text{-}1}$, is a dummy variable coded 1 if carrier $i$ was a member of any explicit constellation in the previous year and 0 otherwise. Participation in explicit constellations is likely to involve sunk investments in contractual procedures, brand name, and information technology, which tend to increase the likelihood that firms will continue participating in such groups. The second instrument, $TiesExplicit_{it}$, measures the proportion of carrier $i$'s bilateral ties at $t$ that are to carriers belonging to any explicit constellation in that period. Members of an explicit group may attempt to lure new firms to which they have bilateral ties (Gomes-Casseres, 1996: 66). After including all control variables, these instruments are uncorrelated with the performance variable, load factor. Taking the sub-sample of members of any explicit constellation in a given year, I next run an OLS regression of $LoadFactor_{it}$ on the inverse Mills ratio resulting from the Probit regression plus the set of controls (except for the multimarket contact variables, which are not included in the Probit equation).[37]

The second problem with the random-effects specification of (3) is that constellation- ($\boldsymbol{x}(C_j)$) and member-specific attributes ($\boldsymbol{z}_i(C_j)$) may be endogenous. Namely, unobserved firm-specific attributes may be correlated with both performance and those explanatory variables. For instance, some firms may have superior competence not only to manage airline operations but also to select partners, which may in turn influence group attributes (e.g., total traffic). Ideally, if endogeneity is present, one should model (3) as a system of equations using instruments to

[37] Some firms are not included in the regressions for implicit groups in cases where the clustering algorithm fails to find a stable pattern of membership for those firms in a given year. Since this is a consequence of the clustering algorithm rather than an issue of self-selection, I do not employ the Heckman two-stage approach in regressions for implicit constellations.

identify the process generating all constellation- and member-specific attributes. However, I was unable to specify such a model due to the lack of enough satisfactory instruments. In an attempt to assess the robustness of the results, I employ alternatively a standard fixed-effects specification by removing within-carrier means, which satisfactorily removes fixed carrier-specific unobserved heterogeneity ($\alpha_i$).[38] However, estimating a dynamic model like (3) with fixed effects may generate inconsistent estimates due to the use of the lagged dependent variable as an explanatory term, as discussed by Nickell (1981). To avoid this effect, I drop the lagged dependent variable when using fixed effects.[39]

## RESULTS AND DISCUSSION

### Characterization of implicit and explicit constellations

Table 5 shows the evolution and the composition of explicit constellations. The period under analysis in this study has witnessed the progressive emergence of several constellations involving key international players, and the dissolution of some groups. In general, firms do not belong to more than one explicit constellation in a given year. There are some exceptions, though membership in more than one group appears to be an unstable pattern. For instance, Delta and Swissair formed the Atlantic Excellence group in 1997 while still members of the Global Excellence group with Singapore Airlines, but the latter soon departed and later joined the Star Alliance. Also, Swissair, Austrian Airlines and Sabena were members of two groups in 1998 and 1999, Atlantic Excellence (with Delta) and Qualiflyer (with other European carriers). But the Atlantic Excellence group was soon dissolved: Delta exited in 1999 and created another group, SkyTeam, with another major international player, Air France, while Austrian Airlines later switched to the Star Alliance. In instances where a firm belongs to two constellations in a

[38] To be sure, there might be some source of *time-varying* unobserved heterogeneity that is not eliminated with fixed effects. I believe, however, that any unobserved factor that may cause endogeneity bias—e.g., competencies to form and manage alliances—should be fairly fixed in the sample, especially because the observation window is not long.
[39] Gimeno (1999) adopts instead an instrumental variable approach by computing first differences of the lagged dependent variable and then using several lags as instruments. This procedure is problematic here due to the short temporal window of the panel.

given year, I consider that the composition of its group is the union of the set of firms belonging to each constellation.

*<Table 5 around here>*

Table 6 presents the composition of implicit constellations, as determined by the tabu search clustering algorithm, and density tables for each year: diagonal entries represent the density of bilateral ties among firms within each group (i.e., variable $Density_t(C_j)$), whereas off-diagonal entries represent the density of bilateral ties among firms belonging to different groups. In all cases, diagonal values are clearly higher than off-diagonal values, thus suggesting that the algorithm is capturing the operational definition of an implicit constellation as a cluster of firms that have more extensive ties to one another than to firms outside the group. The composition of most implicit constellations changes markedly from period to period, in part because bilateral agreements are terminated and formed at a high rate in the industry (Baker, 2001). There also appears to be some correspondence between the composition of implicit groups and the evolving explicit groups, especially in the last years in the observation window, as depicted in Figure 3.[40] This lends some support to the idea that implicit groups in some cases represent "expanded" versions of explicit constellations.[41]

*<Table 6 around here>*

*<Figure 3 around here>*

**Constellation membership and performance**

Table 7 shows the results of the regressions relating constellation membership to firm performance. Models (1), (2) and (3) refer to the sample of firms belonging to explicit constellations; all models are significant ($p < 0.001$). The random-effects model (1), estimated via GLS, provides support for Hypothesis 1: an increase in the aggregated customer base of the

[40] The graph was drawn using the software *KrackPlot 3.0* (Krackhardt, Blythe, and McGrath, 1994).
[41] It is difficult to ascertain whether implicit groups influence the formation of explicit groups or vice-versa; it may be the case that both effects jointly occur. Based on Tables 5 and 6, it seems that some key members of some clusters (such as American Airlines/British Airways/Quantas and KLM/Northwest) later formalized their agreement. In other cases, the formation of implicit groups appears to be simultaneous to or resulting from the emergence of explicit groups, as in the case of the Star Alliance. A detailed analysis of the determinants of constellation formation, however, is beyond the scope of this paper.

constellation (*TotTraffic*$_t$(*C*$_j$)) significantly increase members' performance ($p$ = 0.049).[42] A carrier is expected to have an increase in its load factor by almost 1 percentage point if the traffic brought by other constellation members increases by 100 billion RPKs. The other constellation-specific attributes are insignificant, thus providing no support for Hypotheses 2 and 3: the resource diversity and the density of bilateral ties within explicit constellations do not have a significant effect on performance. Likewise, all member-specific attributes are insignificant, thus providing no support for Hypotheses 4 to 7: the relative position of firms within explicit constellations, at least with respect to the attributes employed in this study, does not explain interfirm performance differences.

*<Table 7 around here>*

To test for the presence of selectivity bias involving the sub-sample of explicit constellations, model (2) is a two-stage Heckman model where the first stage (a) estimates, via Probit, the decision to join an explicit constellation, and the second (b) is the OLS performance regression. For the first stage, all instruments are significant: being part of an explicit constellation at $t-1$ (*PastExplicit*$_{it}$) and holding a large proportion of bilateral ties to members of existing explicit constellations (*TiesExplicit*$_{it}$) increases the likelihood of being part of an explicit constellation at $t$. However, when included in the OLS regression, the resulting inverse Mills ratio (*InvMills*$_{it}$) is insignificant, thus suggesting that selectivity bias is not a matter of concern here.

Model (3) is the fixed-effects version of model (1). Support for Hypothesis 1 is robust to the fixed effects specification: *TotTraffic*$_t$(*C*$_j$) remains significantly related to performance ($p$ = 0.0365). Although the variable measuring hub diversity (*DiversHub*$_t$(*C*$_j$)) is significant ($p$ = 0.002), it has a sign that is the opposite of what is predicted in Hypothesis 2: diversity appears to reduce, rather than increase performance. A 1,000 km increase in the average distance between members' main hubs decreases load factors by 0.73 percentage points. This result appears to support opposite arguments, discussed earlier, that diversity makes it more difficult for firms to

[42] Tests for hypothesized effects are one-tailed.

integrate their resources and cooperate. For instance, having firms from distant locations in the group may increase their difficulty in understanding country-specific conditions and monitoring one another. It is also possible that $TotTraffic_t(C_j)$ may be picking part of the effect of increased hub diversity. Thus, even though hub diversity has a direct negative effect on performance, it may have an indirect positive effect by increasing the aggregated traffic of the constellation due to the possibility to exploit complementarities. Some support for this conjecture is found by noting in Table 3 that $DiversHub_t(C_j)$ and $TotTraffic_t(C_j)$ have a significant and positive correlation, around 0.66 ($p < 0.001$). Other constellation-specific variables and all member-specific variables remain insignificant in the fixed-effects specification.

Table 7 also presents the results of regressions including variables related to implicit constellations; all models, (4) and (5), are significant ($p < 0.001$). Model (4) corresponds to random-effects estimates. No constellation-specific attribute is significant, thus providing no support for Hypotheses 1 to 3: general attributes of implicit constellations apparently do not explain interfirm performance differences. However, several member-specific attributes are significant. $RelCapacity_{it}(C_j)$, which measures a carrier's capacity relative to the total capacity of its group, is marginally significant ($p = 0.088$), thus providing moderate support for Hypothesis 4: larger members appear to outperform smaller members. Hypothesis 5 is not supported: the measure of hub dominance adopted in this study, which is a proxy for the control of critical resources, is unrelated to firm performance. The remaining member-specific attributes, related to the structure of a carrier's bilateral ties, are strongly significant. A 10 percent increase in the proportion of a member's bilateral ties that are to firms outside its constellation ($OutsideTie_{it}(C_j)$) enhances its load factor by 0.33 percentage points ($p < 0.001$), thereby lending support to Hypothesis 6. Also, a 10 percentage point increase in the proportion of members to which a certain firm holds bilateral ties ($InsideTie_{it}(C_j)$) increases that firm's load factor by around 0.62 percentage points ($p = 0.003$), thus supporting Hypothesis 7. Notice that the effect of a firm's *total* number of bilateral ties ($EgoTies_{it}$), which is used as a control variable, is significant but negative ($p = 0.001$). These results suggest that superior performance in the context of implicit constellations is not brought by an increase in bilateral ties per se. Rather, it is driven by a balance between within-group ties—which possibly grant a member enhanced influence and access to group resources—and ties to firms outside the group—which possibly yield that member external options.

However, as model (5) shows, these results are not robust to a fixed-effects specification. No constellation- or member-specific variable is significant in this case. This may be due to two causes. First, it may be a consequence of fixed-effects estimation, which is likely to reduce within-firm heterogeneity—more critical in the case of member-specific variables—and magnify the problem of attenuation bias due to measurement error (Johnston and DiNardo, 1997). Notice that variables related to implicit constellations are inherently measured with error due to the rather subjective boundaries of those groups. The second possible cause may be due to the fact that the lagged dependent variable, $LoadFactor_{it-1}$, is not included in the fixed-effects models. Indeed, across all random-effects models this variable is always strongly significant ($p < 0.001$), thus suggesting that adjustment processes do matter in the case of load factors. If I include the lagged dependent variable in the fixed-effects model, then $InsideTie_{it}(C_j)$ regains statistical significance ($p = 0.038$), although both $RelCapacity_{it}(C_j)$ and $OutsideTie_{it}(C_j)$ remain insignificant.

**The effect of group organization**

The final set of hypotheses, 8 and 9, assert that the effects of constellation- and member-specific variables are contingent on group organization. The results of the random-effects models (1) and (4) unambiguously support those hypotheses. Namely, constellation-specific attributes are only significant and hence explain interfirm performance differences when they are related to explicit constellations, which is aligned with Hypothesis 8. Member-specific attributes, by contrast, are only significant in the regression for implicit constellations, thereby supporting Hypothesis 9. Thus, while explicit constellations appear to augment the effect of constellation-specific attributes on firm performance, in implicit constellations the effect of member-specific attributes appears to be more pronounced. Support for the impact of group organization on the role of constellation-specific attributes (Hypothesis 8) is robust to the fixed-effects specification. But member-specific attributes are insignificant in both models (3) and (5), thereby failing to provide robust support for Hypothesis 9. However, the fact that $InsideTie_{it}(C_j)$ becomes significant in the fixed-effects model when that lagged dependent variable is introduced does not allow for a decisive rejection of Hypothesis 9.

## CONCLUSION

### Contributions

This study moves beyond research focusing on isolated networks or the web of alliances surrounding particular firms and shows that there is value in examining the impact of membership in competing constellations. Although past research has studied competing constellations, the performance implications of membership in those groups remains a rather unexplored topic. Following Gomes-Casseres (1994), I outline sources of membership benefits and offer novel hypotheses about how group organization—i.e., whether the constellation is explicit (based on formal, multilateral agreements) or implicit (informal clusters based on the structure of bilateral ties among firms)—affects those sources. Namely, I propose that generic group characteristics, which determine the total value generated by the group, contribute more to explaining interfirm performance differences in explicit constellations than in implicit ones. However, this effect is reversed in the case of member-specific attributes, which allow firms to better capture differential membership benefits within the same group. Thus, both the total value created in constellations and how this value is distributed among members are contingent on patterns of group organization. Evidence from the global airline industry supports this theory.

This study also has important managerial implications. Faced with competing constellations, managers would like to know the performance implications of partnering with a given group of firms. In other words, managers should decide not only whether they should join a constellation, but also which constellation to join. The results presented here show that this decision does matter. Thus, when considering alternative explicit constellations, managers should pay extra attention to general attributes of those groups that are likely to increase the total value generated by the alliance, such as the size of the constellation's aggregated customer base. By contrast, when considering alternative implicit constellations, managers should carefully consider the relative position of the firm within its group, such as its "centrality" based on bilateral ties to several other members, which critically define the firm's ability to reap superior membership benefits.

**Limitations and possible extensions**

This study has important limitations. First, its results are confined to a single industry and thus may not be generalizable to other contexts. Many variables under analysis here are industry-specific, although they relate to general theoretical concepts. Moreover, the international traffic in the airline industry is also heavily regulated, which makes the use of alliances the only way for global airlines to benefit from foreign resources. In other industry contexts, firms may expand their networks and develop their own resources *internally*, i.e., by increasing the size and scope of their operations. I believe, however, that the theoretical framework and the results presented here have applicability in other contexts for several reasons. Even in situations where firms are free to acquire foreign resources, the internalization of large networks within a single firm is either unfeasible or excessively costly (Richardson, 1972). Some resources, such as knowledge of local markets or competencies in specific technical fields are difficult to replicate because they oftentimes result from learning-by-doing processes and demand complex, interdependent skills (Dierickx and Cool, 1989; Reed and DeFillippi, 1990). Acquiring existing firms holding such resources is likely to reduce incentives for innovation, as they will not be subject to market-based selection pressures (Kogut, 2000). For this reason, Nohria and Garcia-Pont (1991) claim that constellations are crucial in *global* contexts precisely because firms cannot hope to fully control and have access to local resources. Furthermore, even in cases where regulation does not prevent the acquisition of foreign resources, firms may be reluctant to do so if they perceive a risk that such investments will be expropriated by discretionary local governments (Henisz, 2000). Thus, there are circumstances where the expansion of networks internally is difficult, and thus membership in constellations becomes an important organizational decision. However, an assessment of the benefits of constellation membership in other industries, particularly in contexts where firms have more freedom to choose alternative organizational modes, is certainly warranted.

Second, the demarcation of the boundaries of implicit constellations is inherently associated with error, which may cause problems in comparing explicit and implicit groups. Of course, this problem is present in any study assessing the boundaries of organizational forms that are not readily observable (Hannan and Freeman, 1989). Thus, the empirical results involving implicit constellations must be taken with caution. For instance, results appear to be sensitive to the chosen number of partitions. Although the tabu search optimization algorithm employed here is an improvement over usual methods such as hierarchical clustering, there is a clear need to define a general criterion for choosing an optimal number of partitions based on the network of bilateral ties. A possible way to do this is to consider the operational definition of an implicit constellation: a set of firms that have more ties to one another than to firms outside the group. Note that, by increasing the number of partitions, it is likely that the density of within-group ties will increase, but at the expense of an increase in the proportion of ties that are to firms outside the group (Bock and Husain, 1950). A "fit" function that captures this tradeoff can be incorporated in the tabu search algorithm and guide the optimization of both the composition of groups and the number of partitions.[43]

Third, the performance measure employed here, load factor, ignores sources of costs other than capacity and focuses on short-term results. Thus, I cannot tell whether the positive externalities attained from constellation membership outweigh the costs to form and manage those groups. This is particularly critical in the case of explicit constellations, since firms may incur substantial expenses to negotiate agreements, establish committees to oversee the affairs of

[43] Lawless and Anderson (1996) incorporate an objective decision rule in the tabu search algorithm to define an optimal number and composition of clusters. But since they study strategic groups rather than networks, their decision rule is not based on the definition of implicit groups presented above.

the group, create common transacting interfaces, and so on. Studies that evaluate sources of costs associated with constellation membership are needed.[44]

Fourth, I cannot ascertain what are the particular mechanisms that are driving the results presented here, even when results are consistent with the theoretical predictions. For instance, do explicit constellations magnify the effect of group-level attributes on performance because multilateral agreements allow for improved coordination, because formalization of the agreement curtails opportunistic behavior, or because groups gain visibility by becoming explicit (e.g., through brand names)? Do the mechanisms that create interfirm performance differences in constellations correspond to the processes described here, i.e., exit (bargaining) and voice? A more microanalytic examination of those processes can largely contribute to our understanding of how constellations are organized and managed.

Finally, this study does not consider the *sustainability* of benefits from constellation membership, in the sense proposed by Barney (1991). As constellations lure new members over time, the size of the customer base and the profile of resources within each group may become similar to other groups (see Nohria and Garcia-Pont, 1991: 109-110). If there are between-constellation differences, members will have incentives to drag members from other constellations or lure new members until such differences are reduced. The only sustainable source of superior performance from constellation membership may be therefore the relative position of firms within their constellations. For instance, firms may benefit mostly from constellation membership in the long-term when they hold difficult-to-imitate resources such as close relationships or critical assets. Future research should attempt to examine, using longer observation windows, those possible dynamic effects.

[44] A possibility, which can be explored in future studies, is to use abnormal returns in *event studies* assessing stock market reactions to public announcements that a particular firm will join a certain constellation, along the lines of the methodology presented in Park and Martin (2001). A potential problem in the case of global constellations is that not all foreign firms are publicly traded, and in several cases not even reliable accounting information is available. Furthermore, even though event studies can be applied to the study of explicit constellations, whose membership profile is public information, their application to implicit constellations, whose boundaries are subjective, is likely to be problematic.

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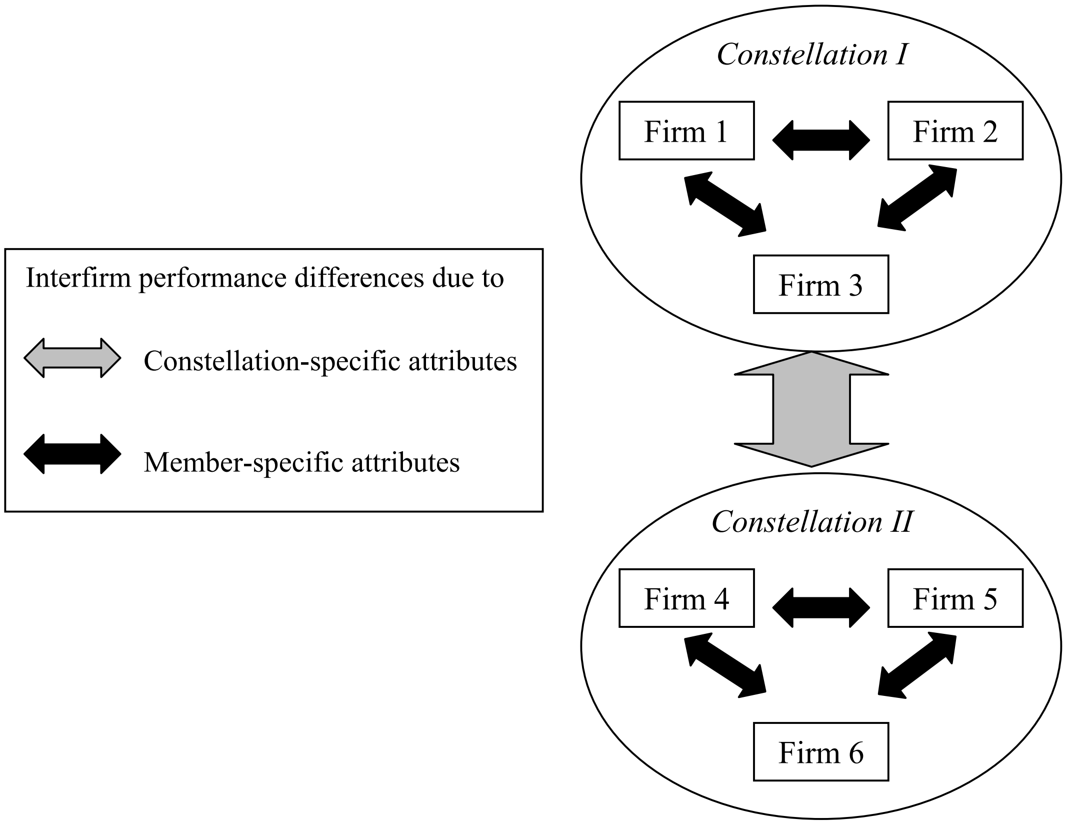


Figure 1. Differential performance stemming from constellation membership

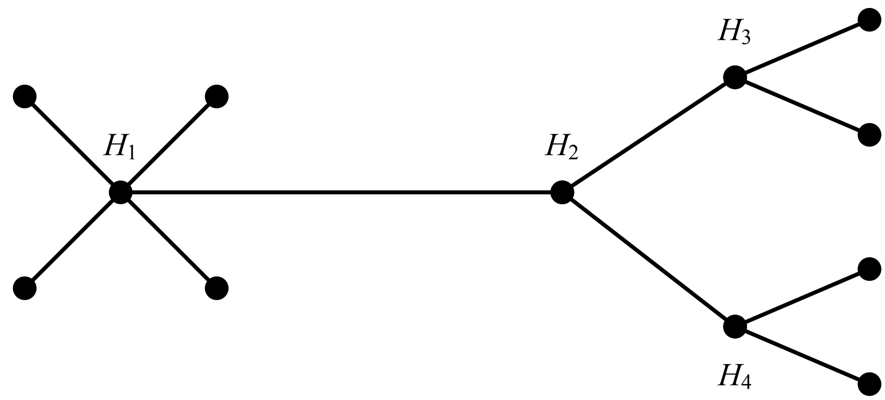


Figure 2.  A hypothetical route network

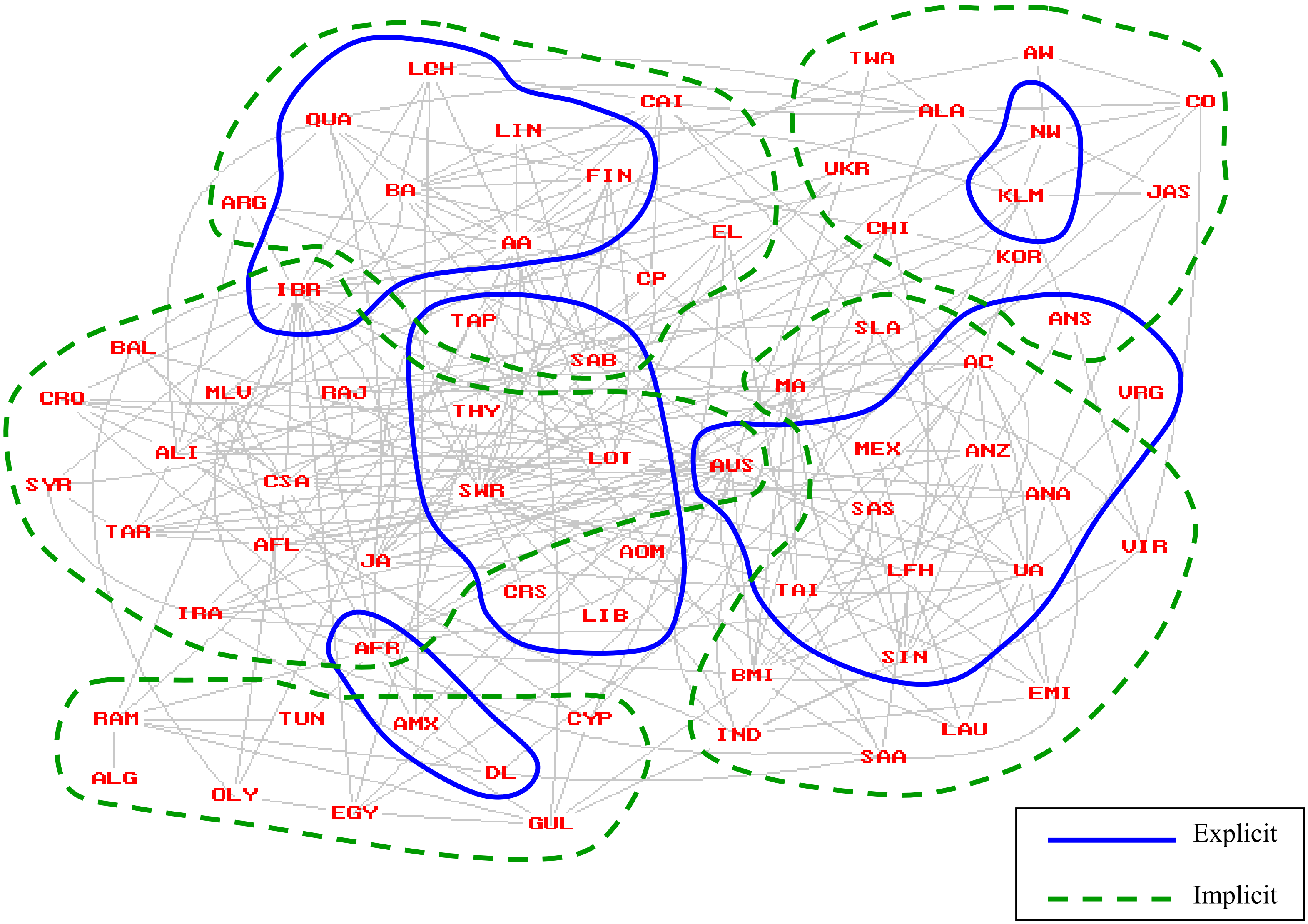


Figure 3. Implicit and explicit airline constellations in 2000

*Note*: Abbreviations of carrier names as indicated in Table 1; gray lines represent bilateral ties.

Table 1. Airline carriers included in the sample

| Carrier name (abbreviation) | Traffic* | Country | Carrier name (abbreviation) | Traffic* | Country |
|---|---|---|---|---|---|
| Aer Lingus (LIN) | 8.889 | Ireland | Japan Air System (JAS) | 15.472 | Japan |
| Aeroflot (AFL) | 16.557 | Russia | Japan Airlines (JA) | 88.999 | Japan |
| Aerolineas Argentinas (ARG) | 11.111 | Argentina | KLM Royal Dutch Airl. (KLM) | 60.331 | Netherlands |
| Aeromexico (AMX) | 14.390 | Mexico | Korean Air (KOR) | 40.467 | South Korea |
| Air Algerie (ALG) | 3.051 | Algeria | LanChile (LCH) | 9.931 | Chile |
| Air Canada (AC) | 44.806 | Canada | Lauda Air (LAU) | 4.562 | Austria |
| Air China (CHI) | 18.116 | China | Lloyd Aero Boliviano (LAB) | 1.701 | Bolivia |
| Air France (AFR) | 91.801 | France | LOT Polish Airlines (LOT) | 4.757 | Poland |
| Air-India (IND) | 12.006 | India | Lufthansa (LFH) | 94.170 | Germany |
| Air Liberte (LIB) | 4.707 | France | Malaysia Airlines (MA) | 37.947 | Malaysia |
| Air New Zealand (ANZ) | 22.232 | New Zealand | Malev Hungarian Airlines (MAL) | 3.168 | Hungary |
| Alaska Airlines (ALA) | 19.273 | United States | Mexicana de Aviacion (MEX) | 13.498 | Mexico |
| Alitalia (ALI) | 40.618 | Italy | Northwest Airlines (NW) | 127.324 | United States |
| All Nippon Airways (ANA) | 58.042 | Japan | Olympic Airways (OLY) | 8.860 | Greece |
| America West Airlines (AW) | 30.742 | United States | Qantas Airways (QUA) | 63.495 | Australia |
| American Airlines (AA) | 187.542 | United States | Royal Air Maroc (RAM) | 7.185 | Morocco |
| Ansett Australia (ANS) | 17.110 | Australia | Royal Jordanian Airlines (RAJ) | 4.207 | Jordan |
| AOM French Airlines (AOM) | 9.248 | France | Sabena (SAB) | 19.379 | Belgium |
| Austrian Airlines (AUS) | 8.799 | Austria | Scandinavian Airlines (SAS) | 22.647 | Sweden |
| Balkan Bulgarian (BAL) | 0.808 | Bulgaria | Saudi Arabian Airlines (SAU) | 20.229 | Saudi Arabia |
| British Airways (BA) | 118.890 | United Kingdom | Singapore Airlines (SIN) | 70.795 | Singapore |
| British Midland (BMI) | 3.837 | United Kingdom | South African Airways (SAA) | 19.321 | South Africa |
| Canadian Airlines Intern. (CAI) | 23.395 | Canada | Sri Lankan Airlines (SLA) | 6.860 | Sri Lanka |
| Cathay Pacific (CP) | 47.097 | Hong Kong | Swissair (SWR) | 34.246 | Switzerland |
| Continental Airlines (CO) | 96.949 | United States | Syrian Arab Airlines (SYR) | 1.422 | Syria |
| Croatia Airlines (CRO) | 0.644 | Croatia | TAP Air Portugal (TAP) | 10.385 | Portugal |
| Crossair (CRS) | 2.073 | Switzerland | TAROM (TAR) | 2.075 | Romania |
| CSA Czech Airlines (CSA) | 3.294 | Czech Republic | Thai Airways International (TAI) | 42.236 | Thailand |
| Cyprus Airways (CYP) | 2.785 | Cyprus | Trans World Airlines (TWA) | 43.798 | United States |
| Delta Air Lines (DL) | 173.411 | United States | Tunisair (TUN) | 2.694 | Tunisia |
| Egyptair (EGY) | 9.086 | Egypt | Turkish Airlines THY (THY) | 16.492 | Turkey |
| El Al (EL) | 14.125 | Israel | Ukraine Intern. Airlines (UKR) | 0.401 | Ukraine |
| Emirates (EMI) | 19.413 | Un. Arab Emirates | United Airlines (UA) | 204.187 | United States |
| Finnair (FIN) | 7.460 | Finland | US Airways (USAir) (USA) | 75.380 | United States |
| GB Airways (GB) | 1.971 | United Kingdom | Varig (VRG) | 26.286 | Brazil |
| Gulf Air (GUL) | 12.739 | Bahrain | VASP Brazilian Airlines (VSP) | 4.918 | Brazil |
| Iberia Airlines (IBR) | 40.015 | Spain | Virgin Atlantic Airways (VIR) | 29.471 | United Kingdom |
| Iran Air (IRA) | 6.229 | Iran | | | |

* Passenger traffic in 2000, billion RPK (revenue passenger kilometers), from IATA's *World Air Transport Statistics*.

Table 2. Description of variables

| Measure | Description |
|---|---|
| <u>*Performance*</u> | |
| $LoadFactor_{it}$ | Load factor: the ratio of carrier *i*'s total traffic (RPK) to its overall traffic capacity (ASK) at year *t* (%). |
| <u>*Constellation-specific attributes*</u> | |
| $TotTraffic_t(C_j)$ | Total passenger traffic (sum of members' RPKs, billion) of constellation $C_j$ at *t*, excluding carrier *i*'s individual traffic. |
| $DiversHub_t(C_j)$ | The average distance (1,000 km) between the major hubs of all carrier-pairs within constellation $C_j$ at *t*. |
| $DiversIntPos_t(C_j)$ | The standard deviation of individual carriers' international positioning (percentage of RPK due to international traffic) for members of constellation $C_j$ at *t*. |
| $Density_t(C_j)$ | Density of the network of bilateral ties within constellation $C_j$ at *t*. |
| <u>*Member-specific attributes*</u> | |
| $RelCapacity_{it}(C_j)$ | The ratio of carrier *i*'s passenger capacity (ASK) to the total capacity of its constellation $C_j$ at *t*. |
| $DomHub_{it}(C_j)$ | Roughly speaking, carrier *i*'s dominance of the traffic involving cities in the route network of constellation $C_j$ weighted by the relative importance of those cities/hubs in aggregating traffic. |
| $InsideTie_{it}(C_j)$ | Proportion of members of constellation $C_j$ to which carrier $i \in C_j$ has bilateral ties at *t*. |
| $OutsideTie_{it}(C_j)$ | Proportion of carrier *i*'s bilateral ties that are to firms outside its constellation $C_j$ at *t*. |
| <u>*Control variables*</u> | |
| $Capacity_{it}$ | Carrier *i*'s capacity (billion ASK) at *t*. |
| $Employees_{it}$ | Carrier *i*'s number of employees at *t* (thousands). |
| $Routes_{it}$ | Carrier *i*'s number of serviced routes at *t* (thousands). |
| $Cargo_{it}$ | Ratio of carrier *i*'s cargo flight activity (RTK) to its number of employees (thousands) at *t*. |
| $Age_{it}$ | Time elapsed, at *t*, since carrier *i*'s founding. |
| $EgoTies_{it}$ | Number of direct bilateral ties of carrier *i* at *t*. |
| $EgoTraffic_{it}$ | Aggregated traffic (billion RPK) of carriers to which carrier *i* has direct bilateral ties at *t*. |
| $Contact_{it}(C_j)$ | Average number of international route contacts between carrier *i* and other members of its constellation $C_j$ at *t*. |
| $GrContact_t(C_j)$ | Average number of international route contacts among members of constellation $C_j$ at *t*. |
| $GDPCap_{it}$, | GDP per capita of carrier *i*'s country at *t* (US$ 1,000). |
| $GDPGrow_{it}$ | GDP growth (%) of carrier *i*'s country at *t*. |
| $Pop_{it}$ | Population (billion inhabitants) of carrier *i*'s country at *t*. |
| $Year(t)$ | Set of dummy variables coded 1 if the observation is from year *t* and 0 otherwise. |

*Note*: ASK = available seat kilometers; RPK = revenue passenger kilometers.

Table 3. Summary statistics: explicit groups ($N = 86$)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.$LoadFactor_{it}$ | 1. | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.$TotTraffic_{t}$ | .14 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.$DiversHub_{t}$ | .27 | .66 | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.$DiversIntPos_{t}$ | -.16 | -.57 | -.43 | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 5.$Density_{t}$ | .17 | -.35 | .24 | .23 | 1 | | | | | | | | | | | | | | | | | | | | | | |
| 6.$RelCapacity_{it}$ | .30 | -.46 | .09 | .14 | .51 | 1 | | | | | | | | | | | | | | | | | | | | | |
| 7.$DomHub_{it}$ | .11 | -.29 | .03 | .20 | .42 | .38 | 1 | | | | | | | | | | | | | | | | | | | | |
| 8.$InsideTie_{it}$ | .32 | -.28 | .20 | .21 | .70 | .54 | .55 | 1 | | | | | | | | | | | | | | | | | | | |
| 9.$OutsideTie_{it}$ | .14 | -.10 | .23 | .04 | .40 | .33 | .41 | .34 | 1 | | | | | | | | | | | | | | | | | | |
| 10.$Capacity_{it}$ | .32 | -.14 | .34 | -.14 | .30 | .86 | .26 | .49 | .22 | 1 | | | | | | | | | | | | | | | | | |
| 11.$Employees_{it}$ | .29 | -.11 | .33 | -.21 | .26 | .80 | .30 | .47 | .24 | .98 | 1 | | | | | | | | | | | | | | | | |
| 12.$Routes_{it}$ | .11 | -.02 | .21 | -.16 | .11 | .35 | .71 | .37 | .32 | .50 | .53 | 1 | | | | | | | | | | | | | | | |
| 13.$Cargo_{it}$ | .31 | .18 | .33 | -.07 | .15 | -.01 | .14 | .08 | .07 | .05 | -.06 | .22 | 1 | | | | | | | | | | | | | | |
| 14.$Age_{it}$ | .15 | .10 | .22 | -.16 | .20 | .36 | .43 | .32 | .41 | .37 | .41 | .46 | -.12 | 1 | | | | | | | | | | | | | |
| 15.$EgoTies_{it}$ | .19 | .05 | .06 | .10 | .01 | .15 | .36 | .50 | .49 | .24 | .27 | .41 | -.05 | .33 | 1 | | | | | | | | | | | | |
| 16.$EgoTraffic_{it}$ | .29 | .48 | .42 | -.15 | -.05 | -.12 | .13 | .32 | .37 | .05 | .07 | .19 | .19 | .24 | .68 | 1 | | | | | | | | | | | |
| 17.$Contact_{it}$ | .10 | -.15 | .19 | -.29 | .27 | .30 | .27 | .19 | .37 | .26 | .29 | .30 | .09 | .14 | -.07 | -.08 | 1 | | | | | | | | | | |
| 18.$GrContact_{t}$ | .14 | -.18 | .15 | -.16 | .20 | .45 | .59 | .37 | .37 | .50 | .52 | .70 | .17 | .28 | .24 | .07 | .70 | 1 | | | | | | | | | |
| 19.$GDPCap_{it}$, | -.02 | -.24 | .04 | .20 | .29 | .38 | .47 | .50 | .08 | .39 | .36 | .32 | .02 | .00 | .31 | .01 | .06 | .35 | 1 | | | | | | | | |
| 20.$GDPGrow_{it}$ | .32 | .13 | .21 | .06 | .14 | .10 | -.14 | .14 | -.06 | .13 | .05 | -.16 | .32 | -.01 | -.05 | .20 | -.17 | -.13 | .12 | 1 | | | | | | | |
| 21.$Pop_{it}$ | .18 | -.22 | .16 | -.07 | .26 | .83 | .12 | .31 | .04 | .86 | .85 | .29 | -.14 | .31 | .03 | -.17 | .21 | .30 | .21 | .02 | 1 | | | | | | |
| 22.*Year96* | -.01 | -.14 | .22 | .30 | .35 | .15 | .15 | .25 | .16 | .07 | .02 | .03 | .12 | -.03 | .05 | .01 | .00 | .00 | .16 | .02 | .04 | 1 | | | | | |
| 23.*Year97* | -.05 | -.09 | .00 | -.05 | .30 | .04 | .06 | .24 | .17 | .05 | .05 | .15 | .07 | -.02 | .05 | -.02 | .47 | .32 | .06 | -.06 | .00 | -.07 | 1 | | | | |
| 24.*Year98* | -.08 | -.17 | -.31 | -.19 | -.15 | -.06 | -.07 | -.10 | -.21 | -.09 | -.06 | -.05 | -.10 | -.12 | -.07 | -.21 | -.11 | -.07 | -.03 | -.26 | -.01 | -.09 | -.17 | 1 | | | |
| 25.*Year99* | -.06 | -.03 | .06 | -.01 | -.19 | .02 | .01 | -.16 | .14 | .03 | .04 | .04 | -.07 | .03 | -.05 | -.05 | .14 | .10 | -.01 | -.16 | .02 | -.11 | -.22 | -.28 | 1 | | |
| 26.*Year00* | .19 | .33 | .02 | -.01 | -.17 | -.11 | -.11 | -.12 | -.19 | -.05 | -.05 | -.12 | .02 | .11 | .05 | .24 | -.39 | -.26 | -.14 | .37 | -.04 | -.15 | -.28 | -.35 | -.47 | 1 | |
| 27.$LoadFactor_{it-1}$ | .90 | .02 | .18 | -.15 | .10 | .32 | .09 | .27 | .10 | .33 | .30 | .09 | .26 | .05 | .15 | .21 | .14 | .16 | -.02 | .24 | .20 | -.05 | -.13 | -.03 | .09 | .07 | 1 |
| Mean | 70 | 273 | 7.0 | .27 | .60 | .18 | 9.3 | .60 | .60 | 75 | 26 | 279 | .02 | 57 | 9.2 | 353 | 11 | 11 | 23 | 3.5 | 74 | .03 | .12 | .17 | .27 | .37 | 69 |
| Std. Dev. | 5.4 | 171 | 3.7 | .06 | .22 | .20 | 7.8 | .31 | .24 | 80 | 26 | 201 | .05 | 20 | 5.4 | 171 | 5.7 | 8.5 | 10 | 2.8 | 97 | .18 | .32 | .38 | .45 | .49 | 5.4 |

Table 4. Summary statistics: implicit groups ($N = 401$)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.$LoadFactor_{it}$ | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.$TotTraffic_{t}$ | .14 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.$DiversHub_{t}$ | .26 | .64 | 1 | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.$DiversIntPos_{t}$ | .14 | .26 | .38 | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 5.$Density_{t}$ | -.01 | .49 | -.06 | -.41 | 1 | | | | | | | | | | | | | | | | | | | | | | |
| 6.$RelCapacity_{it}$ | .35 | -.26 | .01 | .06 | -.10 | 1 | | | | | | | | | | | | | | | | | | | | | |
| 7.$DomHub_{it}$ | .24 | -.21 | -.04 | .03 | -.09 | .56 | 1 | | | | | | | | | | | | | | | | | | | | |
| 8.$InsideTie_{it}$ | .17 | .21 | -.04 | -.25 | .55 | .19 | .20 | 1 | | | | | | | | | | | | | | | | | | | |
| 9.$OutsideTie_{it}$ | .19 | -.23 | -.01 | .20 | -.30 | .18 | .22 | -.32 | 1 | | | | | | | | | | | | | | | | | | |
| 10.$Capacity_{it}$ | .38 | .09 | .25 | .17 | .08 | .85 | .46 | .29 | .10 | 1 | | | | | | | | | | | | | | | | | |
| 11.$Employees_{it}$ | .35 | .02 | .19 | .13 | .06 | .84 | .54 | .30 | .11 | .95 | 1 | | | | | | | | | | | | | | | | |
| 12.$Routes_{it}$ | .27 | -.04 | -.03 | -.03 | .11 | .52 | .81 | .37 | .15 | .57 | .65 | 1 | | | | | | | | | | | | | | | |
| 13.$Cargo_{it}$ | .23 | .11 | .09 | .04 | .08 | .12 | .14 | .05 | .03 | .14 | .04 | .15 | 1 | | | | | | | | | | | | | | |
| 14.$Age_{it}$ | .13 | -.01 | -.05 | .02 | .09 | .31 | .45 | .31 | .03 | .30 | .37 | .46 | -.07 | 1 | | | | | | | | | | | | | |
| 15.$EgoTies_{it}$ | .22 | .16 | -.10 | -.25 | .49 | .22 | .28 | .81 | .12 | .31 | .32 | .47 | .09 | .31 | 1 | | | | | | | | | | | | |
| 16.$EgoTraffic_{it}$ | .28 | .46 | .26 | -.07 | .47 | .06 | .05 | .64 | .06 | .22 | .17 | .15 | .16 | .17 | .71 | 1 | | | | | | | | | | | |
| 17.$Contact_{it}$ | .03 | .55 | .36 | .11 | .20 | -.05 | -.05 | .05 | -.08 | .18 | .15 | .16 | .01 | .05 | .08 | .14 | 1 | | | | | | | | | | |
| 18.$GrContact_{t}$ | .27 | .12 | .16 | .05 | .08 | .40 | .54 | .31 | .14 | .56 | .59 | .79 | .17 | .30 | .40 | .19 | .42 | 1 | | | | | | | | | |
| 19.$GDPCap_{it}$, | .44 | .27 | .28 | .29 | .07 | .45 | .20 | .23 | .07 | .55 | .45 | .26 | .10 | .11 | .28 | .37 | .20 | .28 | 1 | | | | | | | | |
| 20.$GDPGrow_{it}$ | .22 | .01 | .07 | .03 | -.07 | .00 | -.06 | -.05 | -.01 | .02 | .03 | -.09 | .09 | .00 | -.08 | .00 | -.08 | -.08 | -.02 | 1 | | | | | | | |
| 21.$Pop_{it}$ | .00 | .08 | .05 | .12 | .05 | .19 | -.03 | -.04 | .07 | .23 | .26 | .01 | -.03 | -.08 | .00 | .00 | .03 | .02 | .02 | .19 | 1 | | | | | | |
| 22.*Year96* | -.04 | -.02 | .06 | .13 | -.26 | -.01 | -.07 | -.06 | -.15 | -.02 | -.02 | -.01 | -.02 | -.03 | -.10 | -.11 | -.07 | -.03 | .01 | .06 | .00 | 1 | | | | | |
| 23.*Year97* | .03 | -.06 | .01 | -.01 | -.11 | .00 | .01 | .00 | -.15 | -.01 | -.01 | .03 | .01 | -.01 | -.06 | -.07 | .19 | .09 | .00 | -.01 | -.04 | -.21 | 1 | | | | |
| 24.*Year98* | -.03 | -.01 | .00 | .02 | -.01 | .00 | .01 | .04 | -.02 | .00 | .00 | -.01 | -.02 | -.01 | .03 | -.01 | -.08 | -.03 | -.02 | -.15 | .00 | -.21 | -.20 | 1 | | | |
| 25.*Year99* | .00 | .09 | -.04 | .02 | .31 | .01 | .04 | .19 | -.07 | .03 | .02 | .00 | .03 | .02 | .10 | .12 | -.13 | -.06 | .01 | -.05 | .02 | -.20 | -.20 | -.20 | 1 | | |
| 26.*Year00* | .11 | .14 | .01 | -.28 | .31 | .01 | .00 | .19 | -.01 | .04 | .02 | -.03 | .04 | .03 | .15 | .25 | -.26 | -.11 | .02 | .17 | .01 | -.20 | -.20 | -.20 | -.19 | 1 | |
| 27.$LoadFactor_{it-1}$ | .89 | .12 | .25 | .16 | -.03 | .33 | .24 | .15 | .16 | .36 | .34 | .26 | .22 | .08 | .20 | .23 | .00 | .26 | .43 | .15 | -.03 | -.05 | .01 | .08 | .04 | .04 | 1 |
| Mean | 67 | 389 | 6.4 | .25 | .31 | .07 | 4.6 | .29 | .43 | 43 | 17 | 208 | .02 | 51 | 7.0 | 25 | 4.8 | 4.8 | 15 | 3.4 | 96 | .17 | .17 | .17 | .16 | .16 | 67 |
| Std. Dev. | 6.3 | 178 | 2.4 | .06 | .08 | .09 | 4.8 | .18 | .26 | 57 | 19 | 169 | .05 | 20 | 4.4 | 171 | 1.6 | 3.9 | 12 | 3.1 | 189 | .38 | .37 | .38 | .37 | .37 | 5.9 |

Table 5. Description of explicit constellations

| Year | Name | Date founded | Total traffic[a] | Diversity: Posit[c] | Diversity: Hub[b] | Density | Members[d] |
|---|---|---|---|---|---|---|---|
| 1995 | Global Excellence | 1990 | 205.09 | 0.34 | 11.29 | 1.00 | DL, SIN, SWR. |
| 1996 | Global Excellence | 1990 | 226.14 | 0.36 | 11.29 | 1.00 | DL, SIN, SWR. |
| 1997 | Atlantic Excellence | Feb 1997 | 203.08 | 0.33 | 4.11 | 1.00 | AUS, DL, SAB, SWR. |
| | Global Excellence[e] | 1990 | 240.68 | 0.36 | 11.29 | 1.00 | DL, SIN, SWR. |
| | Star Alliance | May 1997 | 354.58 | 0.20 | 7.28 | 0.60 | AC, LFH, SAS, TAI, UA.[f] |
| 1998 | Atlantic Excellence | Feb 1997 | 216.82 | 0.33 | 4.11 | 1.00 | AUS, DL, SAB, SWR. |
| | Qualiflyer | May 1998 | 87.75 | 0.26 | 1.20 | 0.46 | AOM, AUS, CRS, LAU, SAB, SWR, TAP, THY. |
| | Star Alliance | May 1997 | 394.47 | 0.19 | 8.40 | 0.53 | AC, LFH, SAS, TAI, UA, VRG. |
| 1999 | Atlantic Excellence[g] | Feb 1997 | 225.87 | 0.33 | 2.85 | 0.67 | AUS, DL, SAB, SWR. |
| | Oneworld | Sep 1998 | 422.32 | 0.24 | 10.65 | 0.50 | AA, BA, CAI, CP, QUA.[h] |
| | Qualiflyer | May 1998 | 91.28 | 0.27 | 1.28 | 0.48 | AOM, AUS, CRS, SAB, SWR, TAP, THY.[i] |
| | Star Alliance | May 1997 | 445.49 | 0.26 | 10.59 | 0.50 | AC, ANZ, ANS, LFH, SAS, TAI, UA, VRG. |
| | "Wings"[j] | 1999 | 177.52 | 0.28 | 6.68 | 1.00 | KLM, NW. |
| 2000 | Oneworld | Sep 1998 | 483.32 | 0.20 | 9.48 | 0.61 | LIN, AA, BA, CP, FIN, IBR, LCH, QUA. |
| | Qualiflyer | May 1998 | 101.29 | 0.36 | 1.25 | 0.39 | LIB, AOM, CRS, LOT, SAB, SWR, TAP, THY.[k] |
| | SkyTeam | Sep 1999 | 279.60 | 0.27 | 6.13 | 1.00 | AMX, AFR, DL.[l] |
| | Star Alliance | May 1997 | 624.81 | 0.25 | 10.00 | 0.42 | AC, ANZ, ANA, ANS, AUS, LFH, MEX, SAS, SIN, TAI, UA, VRG. |
| | "Wings" | 1999 | 187.66 | 0.27 | 6.68 | 1.00 | KLM, NW. |

*Notes*:
[a] See description of variable *TotTraffic*$_t$(.), Table 2.
[b] See description of variable *DiversHub*$_t$(.), Table 2.
[c] See description of variable *DiversIntPos*$_t$(.), Table 2.
[d] Abbreviations of names as listed in Table 1.
[e] Dissolved in November 1997.
[f] Varig joined the group in October 1997.
[g] Dissolved in November 1999.
[h] Finnair and Iberia joined the group in September 1999.
[i] Air Europe is also a member, but was not included in the analysis due to missing data. However, estimates indicate that it contributes to only about 6.2% of the constellation's total traffic.
[j] "Wings" is an unofficial name of the group. The alliance between KLM and Northwest exists since 1989, but I consider that the group was only officially institutionalized with the announcement that Continental and Alitalia would join the group in early 1999, which was later called off.
[k] Air Littoral, Portugalia and Volare are also members, but were not included in the analysis due to missing data. However, estimates indicate that they, together, contribute to only about 2.4% of the constellation's total traffic.
[l] Korean Airlines joined the group in July 2000.
*Sources*: IATA's *World Air Transport Statistics*; *Airline Business*, several issues; analyses by the author.

Table 6. Description of implicit constellations

| Year/ | Code | Total traffic[a] | Diversity Hub[b] | Diversity Posit[c] | Members[d] | Density table[e] 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1995 | 1 | 413.71 | 4.84 | 0.39 | LIN, AMX, ALA, AW, BA, CO, GB, KLM, MEX, NW, USA. | *.22* | | | | |
| | 2 | 431.46 | 3.95 | 0.23 | AFL, AC, CHI, AFR, ANA, AUS, BAL, CSA, DL, FIN, IBR, LOT, LFH, MLV, SAB, SWR, TAR, THY. | .04 | *.36* | | | |
| | 3 | 317.06 | 8.79 | 0.30 | ARG, IND, ANS, BMI, EMI, MA, RAJ, SLA, TAP, TWA, UA, VIR. | .00 | .06 | *.24* | | |
| | 4 | 129.38 | 3.37 | 0.19 | ALG, ALI, CYP, EGY, GUL, IRA, KOR, OLY, RAM, SAU, SYR, TUN. | .03 | .06 | .04 | *.23* | |
| | 5 | 510.21 | 10.50 | 0.25 | ANZ, AA, CAI, CP, JAS, JA, LAB, QUA, SAS, SIN, SAA, TAI, VRG, VSP. | .04 | .06 | .04 | .02 | *.23* |
| 1996 | 1 | 456.39 | 8.33 | 0.30 | LIN, LIB, ANZ, AW, BA, CAI, GB, LCH, NW, QUA, SAS, USA, VRG. | *.22* | | | | |
| | 2 | 119.66 | 4.73 | 0.19 | AFL, AMX, ALG, AFR, BAL, CRO, EGY, MEX, RAM, TUN, THY. | .00 | *.24* | | | |
| | 3 | 480.78 | 8.96 | 0.30 | ARG, AA, ANS, BMI, CP, JAS, JA, MA, RAJ, SIN, SAA, SLA, TAP, TAI, VIR. | .05 | .01 | *.25* | | |
| | 4 | 522.58 | 4.98 | 0.27 | AC, CHI, ALI, ANA, AUS, CO, CSA, DL, FIN, IBR, KOR, LAU, LOT, LFH, MLV, SAB, SWR, TAR. | .05 | .06 | .08 | *.35* | |
| | 5 | 357.94 | 6.64 | 0.26 | IND, CYP, EMI, GUL, IRA, KLM, LAB, OLY, SAU, SYR, TWA, UA, VSP. | .03 | .03 | .04 | .04 | *.22* |
| 1997 | 1 | 529.65 | 7.05 | 0.35 | LIN, CHI, ALA, AW, DL, EL, FIN, KLM, KOR, NW, SAB, SIN, TAP. | *.26* | | | | |
| | 2 | 281.95 | 3.20 | 0.21 | AFL, AMX, AFR, ALI, AUS, BAL, CO, CRO, CSA, IBR, LOT, MLV, SWR, TAR, THY, UKR. | .08 | *.39* | | | |
| | 3 | 531.64 | 8.83 | 0.22 | ARG, AC, IND, ANZ, ANS, BMI, CP, EMI, LAU, LFH, MA, SAS, SAA, SLA, TAI, UA, VIR. | .04 | .05 | *.29* | | |
| | 4 | 80.37 | 4.86 | 0.19 | ALG, CYP, EGY, GUL, IRA, LAB, OLY, RAM, SAU, SYR, TUN, VSP. | .01 | .06 | .03 | *.20* | |
| | 5 | 543.78 | 9.08 | 0.31 | LIB, ANA, AA, BA, CAI, GB, JAS, JA, MEX, QUA, VRG. | .04 | .04 | .07 | .01 | *.25* |
| 1998 | 1 | 112.22 | 3.94 | 0.22 | LIN, AOM, CRO, EGY, LAU, MA, OLY, RAJ, SAB, SLA, TAP, THY. | *.20* | | | | |
| | 2 | 453.14 | 4.63 | 0.21 | AFL, AMX, CHI, AFR, IND, ALI, AUS, BAL, CSA, DL, FIN, IBR, KOR, LOT, MLV, SWR, TAR, UKR. | .10 | *.39* | | | |
| | 3 | 603.75 | 9.16 | 0.31 | ARG, AW, AA, BA, CAI, CO, JAS, JA, LCH, LAB, QUA, VSP. | .01 | .07 | *.26* | | |
| | 4 | 273.25 | 5.39 | 0.32 | ALG, ALA, CYP, GUL, IRA, KLM, NW, RAM, SAU, SYR, TWA, TUN. | .03 | .06 | .03 | *.23* | |
| | 5 | 576.00 | 9.29 | 0.25 | AC, ANZ, ANA, ANS, BMI, EMI, LFH, MEX, SAS, SIN, SAA, TAI, UA, VIR. | .06 | .06 | .05 | .02 | *.38* |
| 1999 | 1 | 88.46 | 2.20 | 0.23 | LIN, ALG, AOM, CYP, EL, FIN, OLY, RAM, SAB, TAP, TUN. | *.24* | | | | |
| | 2 | 432.07 | 4.98 | 0.22 | AFL, AMX, CHI, AFR, IND, AUS, BAL, CSA, DL, IBR, KOR, LOT, MLV, SWR, TAR, UKR. | .09 | *.41* | | | |
| | 3 | 639.17 | 9.57 | 0.25 | AC, ANZ, ANA, ANS, BMI, EMI, LFH, MEX, SAS, SIN, SAA, TAI, UA, VRG, VIR. | .01 | .05 | *.42* | | |
| | 4 | 840.43 | 8.16 | 0.33 | ALA, ALI, AW, AA, BA, CAI, CO, JAS, JA, KLM, LCH, NW, QUA. | .05 | .10 | .05 | *.38* | |
| | 5 | 126.57 | 4.91 | 0.27 | CRO, EGY, GUL, IRA, MA, RAJ, SLA, SYR, TWA, THY. | .03 | .11 | .07 | .04 | *.31* |
| 2000 | 1 | 521.70 | 8.68 | 0.18 | LIN, ARG, AA, BA, CAI, CP, EL, FIN, LCH, QUA, SAB, TAP. | *.41* | | | | |
| | 2 | 364.13 | 2.54 | 0.15 | AFL, AFR, ALI, AUS, BAL, CRO, CSA, IBR, IRA, JA, LOT, MLV, RAJ, SWR, SYR, TAR, THY. | .13 | *.43* | | | |
| | 3 | 234.20 | 5.41 | 0.25 | AMX, ALG, CYP, DL, EGY, GUL, OLY, RAM, TUN. | .05 | .09 | *.22* | | |
| | 4 | 706.03 | 8.36 | 0.20 | AC, IND, ANZ, ANA, BMI, EMI, LAU, LFH, MA, MEX, SAS, SIN, SAA, SLA, TAI, UA, VIR. | .03 | .09 | .03 | *.38* | |
| | 5 | 469.98 | 7.92 | 0.35 | CHI, ALA, AW, ANS, CO, JAS, KLM, KOR, NW, TWA, UKR. | .07 | .06 | .01 | .05 | *.29* |

*Notes*:

[a] See description of variable *TotTraffic*$_t$(.), Table 2.

[b] See description of variable *DiversHub*$_t$(.), Table 2.

[c] See description of variable *DiversIntPos*$_t$(.), Table 2.

[d] Abbreviations of names as listed in Table 1. Composition of groups as revealed by clustering algorithm based on the matrix of bilateral ties among firms.

[e] Diagonal entries indicate density of constellation. Off-diagonal entries indicate density of ties between constellation members and members of other groups.

*Sources*: IATA's *World Air Transport Statistics*; *Airline Business*, several issues; analyses by the author.

Table 7. Constellation membership and performance: regression results

| | Explicit constellations | | | | Implicit constellations | |
|---|---|---|---|---|---|---|
| | Random effects | Heckman two-stage | | Fixed effects | Random effects | Fixed effects |
| | (1) | (2a) Probit | (2b) OLS | (3) | (4) | (5) |
| | $LoadFactor_{it}$ | Prob($Expl_{it}$ = 1) | $LoadFactor_{it}$ | $LoadFactor_{it}$ | $LoadFactor_{it}$ | $LoadFactor_{it}$ |
| <u>Constellation-specific</u> | | | | | | |
| $TotTraffic_t(C_j)$ | 0.009** | - | - | 0.009** | 0.003 | 0.001 |
| | (0.006) | | | (0.005) | (0.002) | (0.002) |
| $DiversHub_t(C_j)$ | -0.075 | - | - | -0.730* | 0.043 | 0.134 |
| | (0.251) | | | (0.221) | (0.109) | (0.113) |
| $DiversIntPos_t(C_j)$ | 11.915 | - | - | 5.778 | -4.524 | -4.943 |
| | (9.990) | | | (7.505) | (4.032) | (3.857) |
| $Density_t(C_j)$ | 1.394 | - | - | -0.563 | 1.771 | -0.408 |
| | (4.262) | | | (4.185) | (3.894) | (3.898) |
| <u>Member-specific</u> | | | | | | |
| $RelCapacity_{it}(C_j)$ | 6.488 | - | - | 10.919 | 6.009† | 4.035 |
| | (6.869) | | | (9.383) | (4.427) | (4.714) |
| $DomHub_{it}(C_j)$ | -0.053 | - | - | -0.082 | -0.032 | -0.017 |
| | (0.103) | | | (0.082) | (0.068) | (0.077) |
| $OutsideTie_{it}(C_j)$ | 0.719 | - | - | -0.339 | 3.262* | -0.287 |
| | (2.518) | | | (2.253) | (0.994) | (1.002) |
| $InsideTie_{it}(C_j)$ | 2.243 | - | - | -2.785 | 6.212* | 2.012 |
| | (2.793) | | | (2.895) | (2.244) | (2.219) |
| <u>Controls</u> | | | | | | |
| $Capacity_{it}$ | -0.006 | 0.006 | -0.008 | -0.018 | -0.008 | 0.071** |
| | (0.039) | (0.008 | (0.021) | (0.105) | (0.014) | (0.036) |
| $Employees_{it}$ | 0.025 | 0.019 | 0.022 | -0.442** | 0.005 | -0.098 |
| | (0.093) | (0.024) | (0.059) | (0.152) | (0.040) | (0.087) |
| $Routes_{it}$ | 0.941 | 0.102 | -1.832 | 18.402† | 0.830 | -1.841 |
| | (4.557) | (1.137) | (2.036) | (9.865) | (2.664) | (4.400) |
| $Cargo_{it}$ | 7.802 | -2.418 | 11.128 | -10.980 | 5.698 | -1.997 |
| | (11.482) | (2.816) | (8.006) | (25.742) | (4.054) | (12.566) |
| $Age_{it}$ | 0.005 | 0.013† | 0.033** | -0.632 | 0.019 | 0.004 |
| | (0.029) | (0.007) | (0.016) | (0.655) | (0.011) | (0.158) |
| $EgoTies_{it}$ | -0.020 | 0.033 | -0.004 | -0.131 | -0.256* | -0.098 |
| | (0.151) | (0.042) | (0.081) | (0.189) | (0.100) | (0.125) |
| $EgoTraffic_{it}$ | -0.001 | 0.000 | 0.001 | 0.004 | 0.002 | 0.004 |
| | (0.004) | (0.001) | (0.003) | (0.003) | (0.002) | (0.002) |
| $Contact_{it}(C_j)$ | 0.024 | - | - | -0.152 | -0.140 | -0.220 |
| | (0.102) | | | (0.080) | (0.159) | (0.150) |
| $GrContact_t(C_j)$ | 0.004 | - | - | -0.087† | 0.003 | -0.013 |
| | (0.070) | | | (0.090) | (0.075) | (0.080) |
| $GDPCap_{it}$, | -0.023 | 0.017 | 0.006 | -0.345 | 0.043** | -0.156† |
| | (0.058) | (0.013) | (0.033) | (0.238) | (0.021) | (0.085) |
| $GDPGrow_{it}$ | 0.176 | 0.029 | 0.069 | 0.259* | 0.173* | 0.225* |
| | (0.125) | (0.043) | (0.119) | (0.085) | (0.048) | (0.047) |
| $Pop_{it}$ | -7.244 | -6.137** | 0.462 | 661.279* | 0.165 | 81.196* |
| | (10.809) | (2.412) | (6.544) | (228.194) | (1.047) | (26.455) |
| $LoadFactor_{it-1}$ | 0.717* | 0.007 | 0.867* | - | 0.792* | - |
| | (0.086) | (0.023) | (0.056) | | (0.033) | |
| $Expl_{it-1}$ | - | 2.469* | - | - | - | - |
| | | (0.332) | | | | |
| $TiesExplicit_{it}$ | - | 2.578* | - | - | - | - |
| | | (0.619) | | | | |
| $InvMills_{it}$ | - | - | -0.370 | - | - | - |
| | | | (0.508) | | | |
| $N$ | 86 | 442 | 86 | 86 | 401 | 401 |
| $\chi^2$ | 31,992.47* | 271.92* | - | - | 1,103.81* | - |
| $F$ | - | - | 23.92* | 7.82* | - | 5.08* |

* $p < 0.01$; ** $p < 0.05$; † $p < 0.10$ (one-tailed tests for hypothesized effects). The table shows parameter estimates and standard errors in parenthesis. All models include year-specific dummy variables.