INTER-ORGANISATIONAL RELATIONS IN LINER SHIPPING AS A COOPERATIVE GAME

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Abstract: In recent years, almost all the liner companies seek extensive cooperation with others reflected mainly by shipping alliances as well as other forms including shipping consortia, and much closer cooperation in mergers and acquisitions. Despite this, there are still some liner companies who prefer the go-it-alone' policy and achieve relative success when compared with a number of liner companies who have, to some extent, failed in their adoption of the cooperative approach. It seems that cooperation is not always necessary for a liner company's success. This paper aims to apply cooperative game theory to analyse the cooperation among members of liner shipping cooperation, and the in-depth rationales behind liner shipping cooperation (or non-cooperation) is studied with the objectives to explain inter-organisational relationship and decision-making behaviour in the liner shipping sector.

Key Words: Liner Shipping Cooperation, Collaboration, Inter-organisational Relation, Cooperative Game Theory

1. INTRODUCTION

The liner shipping market has always been characterised by competition and cooperation among its members since its birth. Competition has mainly taken place as a consequence of common carrier routes which forced many companies to cut prices and thereby engage in destructive price wars. Realising the disadvantages and potentially dangerous consequences of such price wars, companies decided that it would be better to cooperate with each other.

No organisation is completely self-sustained. The propensity of ocean carriers for adopting a cooperative approach as a route for achieving their organisational objectives culminated in recent years in the development of various cooperative inter-organisational agreements and structures. These range from slot and vessel sharing agreements to consortia, joint ventures and even full integration through merger and acquisition (Ryoo and Thanopoulou, 1999).

Liner shipping strategic alliances have been playing a dominant role in the industry over the recent years. Carriers saw many advantages in the formation of alliances and swiftly move to consolidate their position as members of such organisational forms. Hence the formation of alliances like The Grand Alliance, The New World Alliance and The United Alliance. Despite the inclination to enter a strategic alliance and cooperate with other carriers, such alliances have been found to be highly unstable as companies were caught between honouring their cooperative commitments and pursuing their own individual objectives. Indicative of this characteristic has been the year 1996, which saw the formation of no less than four global alliances only for three of them to be re-structured due to switching of their membership within one year of commencing operations. In addition to this, the differing degree of success and failures of liner shipping alliances does suggest that this organisational form may not offer the competitive advantages that individual member companies have been envisaging.

Other forms of interoganisational relationships that seem to play an important role in the liner shipping industry include conference, consortia (which may be deemed as predecessors of shipping alliances) and full scale mergers through acquisitions and take-overs.

Bearing in mind the topicality of the issue, an analysis of the rationale behind liner shipping cooperation would be of particular importance to practitioners in the liner shipping industry as well as for setting a firm basis for the much-needed future academic research. Such an analysis will contribute substantially to the advancement of knowledge bearing in mind that previous scientific study in this regard is quite limited. The purpose of this paper is to make such an analysis by applying a cooperative game theoretic approach to this specific market. Cooperative game theory has been identified to be a very applicable approach towards problems of this nature. A conceptual model, by which the pattern of shipping cooperation and the opportunistic behaviour of each member of the cooperation can be described, will be developed in this paper. The accomplishment of the aforementioned objectives will provide important implications for decision-makers in the industry and an opportunity for further research in this, yet uncharted, area.

2. A BRIEF HISTORY OF LINER SHIPPING COOPERATION

Cooperation among liner shipping companies has mainly taken the form of conferences, consortia, shipping alliances and mergers and acquisitions (M&As).

2.1 Liner Service

Stopford (1997, p. 343) defines a liner service as:

> 'A fleet of ships, with a common ownership or management, which provides a fixed service, at regular intervals, between named ports, and offer transport to any goods in the catchment areas served by those ports and ready for transit by their sailing dates. A fixed itinerary, inclusion in a regular service, and the obligation to accept cargo from all comers and to sail, whether filled or not, on the date fixed by a published schedule are what distinguish the liner from tramp".

As argued by Kadar (1996), the ocean shipping industry is quite stable and it maybe slightly hyperbole to assert that just two revolutionary changes have taken place in the last over 100 years, namely the switch from sail to steam and the introduction of containers. The former could date back to 1870s. The latter was inaugurated on the North Atlantic in April 1966 by Sea-Land. The efficient and reliable service associated with containerisation has propelled the container liner service to develop at a rapid speed. By now all of the major liner routes and most of the minor ones had been containerised because of its unparalleled advantages.

The container liner service has both advantages and disadvantages associated with it. On the one hand it can be very attractive to the customers, the shippers and in extension it is beneficial to the companies in satisfying customer requirements. On the other, the obligation to sail in accordance to a timetable, makes capacity inflexible for liner operators. It is also a risky industry in terms of intensive investment required for asset purchase and changeable requirement of cargoes determined by trade, seasonality and cargo imbalance. Meanwhile, pricing has become a problem for liner companies because of the numerous fragmented markets and competition among liners (Stopford, 1997).

2.2 Shipping Conference

The conference system, which was developed in the mid-1870s, was the industry's first attempt to deal with the pricing problem. According to the UNCTAD Code (Brooks, 2000, p. 3), the liner conference may be defined as:

> 'A group of two or more vessel-operating carriers which provides international liner services for the carriage of goods on a particular route or routes within specified geographical limits and which has an agreement or arrangement, whatever its nature, within the framework of which they operate under uniform or common freight rates and any other agreed conditions with respect to the provision of liner services."

The first conference was formed in the mid-1870s by a number of liner operators who operated on the same trade. Their aim was to curb the intense competitive market by fixing the rate, thereby controlling destructive competition. Over the next century, there has been a constantly evolving network of agreements covering rates, the number of sailings, the ports served, the goods carried and the sharing of freight revenues ('pool' agreement). The conference system reached its peak during 1950s (Stopford, 1997, p. 350) and conferences were the dominant form of liner-organisational structure until the early 1980s (Brooks, 2000).

Obviously the development of shipping conference is to protect the benefits of liners in the conference thus it naturally leads to the discontent of outsiders and shippers. It has been attacked since its outset. The activity of conference has greatly been limited by anti-trust laws in the US and Europe (Stopford, 1997; Brooks, 2000). The legislation weakened the conference system and changed its role; the market share of conference operators has been declining steadily in the past two decades (Brooks, 2000).

2.3 Shipping Consortium

The first consortium formed several years after the birth of container transportation was in response to the large investment in container ships, shore-based handling facilities and of course the container themselves (Stopford, 1997). With its further development, a close inter-firm cooperation of liner operators, mainly including sharing of vessel space, coordination of sailings, and in most cases some form of common commercial/marketing activity, enabled them to promote the rationalisation of shipping activities and improve the services provided. Consortia claim to offer advantages to participating shipping companies through cost reductions derived from economies of scale and to benefit transport users by ensuring more regular and higher services (Button, 1999).

Mainly two reasons lead to the final break-up of consortia in the 1990s. First and foremost, with the process of globalisation in this era, the need for the provision of multimodal and integrated logistical services world-wide were turning consortia, based basically on the principle one route-one consortium', into a too restrictive form. A service highlighting frequency and speed in the context of consortium has proved incapable to providing multimodal, often tailor-made operations in the new just-in-time globalised world of shippers (Thanopoulou, Ryoo and Lee, 1999). Second, the growth of large liners reduced the need for consortium system. Over many years of development, numerous liners got strong enough to survive independently on one or some routes. It is feasible for them to search for larger-scale cooperation to cope with the needs of the shippers.

2.4 Liner Shipping Alliance

With the decline of shipping consortia, the first shipping alliance was formed in 1994 (Stopford, 1997) and developed rapidly in the following years to cater for the process of globalisation (Bhatnagar and Viswanathan, 2000). It is nowadays the dominant form of cooperation among shipping lines.

In contrast with the prominence of shipping alliances, the term shipping alliance' has not been institutionalised (Brooks, 2000). Generally speaking, this distinct cooperation of shipping lines highlights the following (Button, 1999):

> The purpose of participants in a strategic alliance is to establish cooperative agreements on a global basis. Participants include national and cross trades and may embrace conference and non-conference lines. The agreements apply not to one trade route, and not with different carriers on different trade routes, but with the same carriers over certain major routes which can be described global. A strategic alliance embraces at least two of the major east/west trade routes (Europe/Asia, Asia/US, or US/Europe) world service either by combined services on each route or in round-the world service."

Lines have implemented strategic alliances by a series of route agreements because of differences in the regulatory regimes or transportation conditions on each route. The parties agree on the employment and utilisation of vessels; including joint vessel route assignments, itineraries, sailing schedules, the type and size of vessels to be employed, additions and withdrawal of capacity, ports and port rotations, and operations over the global system. They agree on charters, space charters, the use of joint terminals, co-ordination of containers, pooling of containers and establishment of container stations, vessel feeder routes and co-ordinations of inland services (if permitted). The lines may agree on information exchange and procedures. An agreement may place restrictions on a participant's use of third party carriers on the imposed provisions for withdrawal, including notice and penalties, and may contain provisions with respect to ownership changes during the agreement.

2.5 Merger and Acquisition

"Acquisition refers to buying a firm. A merger is a variant of the acquisition. Firms may choose to merge by exchange of shares or capital or both; the new firm is a combination of two or more and who acquired whom may not be clear until well after the merger takes place and the 'wining' management team is chosen (Brooks, 2000, p. 43)."

According to this definition, merger and acquisition may not be strictly classified as cooperation among lines. However, they are hereby discussed because of their impacts on shipping alliances. For instance, the merger between P&O and Nedlloyd, as well as the take-over of APL by NOL led to the reorganisation of shipping alliance (Heaver, Meersman, Moglia and Voorde, 2000). More recently the take-over of Sea-Land by the Maersk Group has also shocked the world liner industry (Lloyd's Shipping Economist, 2000).

Quite similar to the aims of shipping alliance and consortia, these mergers and acquisitions take place to rationalise activities, reduce costs, and create significant economies of scale. Unlike the characteristics of individual identities and instability in the context of shipping alliance and consortia, mergers and acquisitions enable the liner operators to control tightly the assets thus make their operation more stable.

2.6 The Significance of Liner Shipping Cooperation

As evidenced in the aforementioned discussion, inter-firm cooperation was chosen by most liner shipping companies. However, there have been dissenting views relating to the instability of cooperation among the members and the 'go-it-alone' policy adopted by some successful shipping liners, must be accentuated. The year 1996 saw the formation of no less than four global alliances only for three of them to be re-structured due to switching of their membership within one year of commencing operations (Midoro and Pitto, 2000). In the meantime, some global players such as Evergreen and regional players such as Canadian Pacific have been enjoying prosperity by operating independently (Alix, Slack and Comtois, 1999).

The above indicates that shipping cooperation may or may not lead to success for liners, thus the subject matter deserves a thorough study. To this end, the cooperative game theory approach is chosen in our study and its advantage and applicability will be discussed in the following sections.

3. COOPERATIVE GAME THEORY IN LINER SHIPPING ALLIANCE

3.1 Game Theory in General

Game theory was initiated in the early 1940s by Von Neuman and Morgenstern (1944). Since then a large number of applications have been carried out by employing game theoretic frameworks (Schotter and Schwodisuer, 1980; Rubinstein, 1990). In simple terms, game theory is concerned with the study of multi-person decision problems (Gibbons, 1992). Further to this definition, game theory is also concerned with the prediction of outcomes from 'games', which are commercial situations involving two or more players whose interests are interlinked or interdependent (Zagare, 1984). For example, as is commonly recognised, an oligopolistic market situation presents multi-person problems. Each firm in the market must consider what the others will do before setting up a strategy and even during its implementation period. This is simply because a decision made by one party has a direct impact on the others: in other words, the strategies adopted by the players to a game and the effects these have on the game's outcome. The insights the game approach can provide should therefore be of direct relevance for the understanding of cooperative strategy like strategic alliances (Child and Faulkner, 1998).

In a broad sense, game theory can be classified into two categories: *non-cooperative game approaches* (e.g. Tirole, 1988) and *cooperative approaches* (e.g. Curiel, 1997). The former is relevant to a situation where a decision making unit in a market treats the others as competitors, while the latter deals with a situation in which a group of decision makers decide to undertake a project together   all partners joining the project being regarded as collaborators - in order to achieve their joint business objectives: for example, to increase total revenue (profit maximisation) or market shares or to decrease total costs (cost minimisation), as mentioned in the previous section. Under this classification, the cooperative approach is applicable to liner shipping alliances from two perspectives; it considers (i) the underlying motives and reasons for the formation of alliances and (ii) the optimal performance of the partners' business activities.

In game theory, a *player* can be an individual, or a group of individuals, taking a role as a decision-making unit. Individuals or groups become players when their respective decisions, coupled with the decision made by other players, produce an *outcome*. The options available to players to bring about particular outcomes are called *strategies*. Strategies are linked to outcomes by a mathematical function that specifies the consequences of the various combinations of strategy choices by all of the players in a game. Another important concept in cooperative game theory is a *coalition* which refers to the formation of subsets of players' options under coordinated strategies (Zagare, 1984).

According to the definition of game' as mentioned above, the game of liner shipping industry should comprise various players such as liner shipping companies, shippers and port operators, whose interests are interlinked or interdependent. For simplicity, the players in this paper refers to the liners in a market and the simplicity can be validated by the payoff functions of the liner shipping companies which are influenced largely by other players' decisions. Table 1 shows the well-matched relationship between the cooperative game framework and liner shipping alliances, which further justifies an argument that liner shipping alliances can be treated as cooperative games.

Table 1. Cooperative Game and Liner Shipping Alliance

Cooperative Game	Liner Shipping Alliance
Player	Liner Shipping Company
Coalition	Shipping Alliance
Strategy	Daily operation plans to long-term developmental strategy: for example, selecting ship types, operating routes and seeking for a partner in the market
Outcome	Gaining economic benefits and know-hows; Penetrating new markets; and improving and/or sustaining reputations

3.2 Fundamentals of Cooperative Game

There are two key points in cooperative game: (i) what is the payoff for each coalition, and (ii) what the payoff of each player in the coalition should get (Von Neumann and Morgenstern, 1944). To solve the two problems, it is necessary to introduce two other vital concepts in the context of cooperative game: the *characteristic function* and the *core* of an n-player game.

3.2.1 Characteristic Function

Characteristic function abstracts the essential features of the cooperative games (i.e. those most germane to the process of coalition formation) by assigning a value to every possible coalition. The assignment of a value, or payoff, to a coalition is based upon the assumption that each coalition is faced with the worst possible strategic coalition which is closely related to the *maximin* or *minimax* strategy in the context of non-cooperative game (Olson, 1965).

Formally, the characteristic function, U, has the following two properties:

$$U(\phi) = 0 \quad (1)$$

$$U(P_1 \cup P_2) \geq U(P_1) + U(P_2) \quad (2)$$

where ϕ is the empty set (coalition), and P_1 and P_2 are any two non-overlapping (disjoint) players or coalitions

Condition (1) is only a technical restriction; it merely states that a coalition with no members has no value. Condition (2), known as *superadditivity* (Morris, 1994), however, requires that the payoff to a coalition between two players (or coalitions), P_1 and P_2, be at least as good, and perhaps better, than the payoff P_1 and P_2 receive as separate coalitions or individuals.

3.2.2 Core of an n-Player Game

Given the characteristic function, it is natural to ask what each player could get and whether the information contained in the characteristic function has any particular implication for which the coalition will actually form. In the context of cooperative game theory, the answer to one or both of these questions constitutes a *solution*. The *core* of an n-player game is the most prominent one among the numerous (at least twenty) concepts in the literature (Shubik, 1968). The theory of the core has been applied to the unfashionable shipping conference and the equilibrium of shipping liners by various researchers (e.g. Telser (1978; 1987), Pirrong (1992), Sjostrom (1989), Jankowski (1989), Button (1999). Haralambides and Veenstra (2000) provide a summary of those studies.

The core rests upon the idea of an *imputation*. An imputation is an n-tuple of payments to the participants of an n-player game which satisfies both *individual rationality* and *collective rationality* (Morris, 1994). The formal definitions of them are shown as below.

Let U be an n-person game in characteristic function form with players $P=(p_1, p_2,..., p_n)$. An n-tuple $(x_1, x_2,..., x_n)$ of real numbers is said to be an imputation if both the following conditions hold:

- *Individual Rationality*: $x_i \geq U(p_i)$, $i=1, 2, \cdots; n$ (3)
- *Collective Rationality*: $\sum_{i=1}^{n} x_i = U(P)$ (4)

Where condition (3) indicates that no player would accept leas than what he can guarantee himself as given by the characteristic function. Condition (4) states that the sum of payoffs of a group of n-players is equal to value that is guaranteed by the characteristic function.

Any payoff vector satisfying (3) and (4) is named an imputation. The imputation can be thought of as a possible social arrangement that satisfies minimal conditions of rationality. Presumably, any ultimate arrangement will be drawn from the set of imputations. A drawback of the sets of imputations, however, may itself be quite large. Thus *coalition rationality* can be argued as a natural extension of the conditions of individual and collective nationality. Coalition rationality requires that the security level of every coalition defined by characteristic function be satisfied: formally:

$$\sum_{p_i \in C} x_i \geq U(C) \quad \text{for all } C \text{ in } P \tag{5}$$

Where C denotes all the possible coalitions formed by a subset of the n players. For example, C may stand for the coalition (p_1, p_2), or (p_1, p_2, p_3).

The set of imputations satisfying the conditions of the coalition rationality constitutes the core. The rationale behind condition (5) is as follows. Suppose that a coalition, C, forms and attempts to divide the value assigned to C by the characteristic function. Further suppose that a subgroup of C, say C_I, is offered a payoff less than what C_I is worth according to the characteristic function. In this case, C_I would not accept the offer since it can do better without the remaining members of C. Thus, for C_I to remain in the coalition, it should receive at least as much as $U(C_I)$. If this argument is extended to all possible conditions, then the condition of coalition rationality is required.

According to the definition of the core, no individual or group has an opportunity or incentive to overturn a societal arrangement if the imputation is in the core. In other words, given the strategic structure of a game, as defined by the characteristic function, the demands of each player and of each coalition can be satisfied. Imputations in the core, then, are particularly stable.

4. Liner Shipping Cooperation: A Cooperative Game Theoretical Illustration

4.1 Two-Player Cooperative Game

Two-player games have been thoroughly studied in the field of game theory, which provides a starting point for this study. Suppose there are two liner companies, L_1 and L_2, with the only goal of revenue maximisation, operating on the different trade routes of AB' and BC' by adopting the pattern of pendulum network services (L_1: A→B→A, L_2: B→C→B). Annual container volumes between AB' and BC' are 100,000 TEUs respectively, as shown in Figure 1.

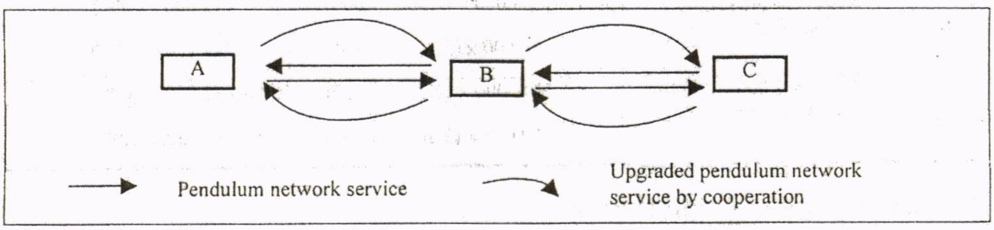

Figure 1. An Example of Liner Shipping Service Network

Containers have transformed liner shipping into a neo-bulk industry because the vessel operator is unconcerned with their contents unless they contain dangerous or refrigerated goods. Therefore the traditional price differentiation for different types of cargo is increasingly giving a way to FAK (freight all kinds) freight-rates in the containerisation era. The tendency toward treating a box as a box as a box' also reflects the declining monopoly power of liner companies and their conferences. In the meantime, earlier studies (Cullinane and Khanna, 1999; Cullinane and Khanna, 2000) reveal that it is also scientific for liners to calculate their costs according to the costs per unit container on each route they operate. Based on the above discussion, the freight rates and costs are defined and their values are artificially given in Table 2.

Table 2. Freight Rates and Costs on Different Legs

Leg	Freight Rate (US$ / TEU)	Cost (US$ / TEU)
A→B (B→A)	2,000	1,000
B→C (C→B)	2,000	1,000
A→C (C→A)	3,800	1,800

With the globalisation trend, some shippers require carriers to provide more efficient services between AC'. The carriers have the following two ways as to the requirement from the shippers: one the one hand, the carriers stick to the current pendulum service; on the other, they form a strategic alliance in order to cooperate with each other. By coordinating departures and adjusting service frequency, they can form a large-scale pattern of pendulum service, that is, A→B→C→B→A. In the latter case, suppose the container volume between AB' and BC' are still 100,000 TEUs respectively per annum. The annual container volume between AC is 50,000 TEUs*.The allocation of revenues is based on the ratio of the shipping capacities of two liners.

Suppose the ratio of the shipping capacities of two liners is one to one (1 : 1). Then the payoffs (revenues) to two liners are shown in Table 3.

* The increased shipping demand is presumed to be generated by the improved service quality because some potential cargoes will not be available until some satisfactory service, such as frequency and capability derived from shipping alliance, is provided' (Brooks, 2000). Hereafter in this paper including the following three-player cooperative games, we suppose that, to some reasonable extent, the cooperation of more liners in the market will generate more cargoes which imply, *ceteris paribus*, more revenues.

Table 3. The Payoffs of a Two-Player Cooperative Game (Capacity Ratio 1 : 1)

	Non-cooperation	*Cooperation*
L_1	100,000 × (2,000 1,000) = US$ 100,000,000	[100,000 × (2,000 1,000)+100,000 × (2,000 1,000)+ 50,000 × (3,800-1,800)] × $\frac{1}{1+1}$ = US$ 150,000,000
L_2	100,000 × (2,000 1,000) = US$ 100,000,000	[100,000 × (2,000 1,000)+100,000 × (2,000 1,000)+ 50,000 × (3,800-1,800)] × $\frac{1}{1+1}$ = US$ 150,000,000

According to the characteristic function:

$$U(L_1) = \text{US\$ } 100{,}000{,}000 \ (< \text{US\$ } 150{,}000{,}000)$$
$$U(L_2) = \text{US\$ } 100{,}000{,}000 \ (< \text{US\$ } 150{,}000{,}000)$$

Under this case, the two liners will take the cooperative strategy since they can be better off by cooperation. On the other hand, if the ratio of the shipping capacities of two liners is one to three (1 : 3), Then the payoffs to two liners are shown in Table 4.

Table 4. The Payoffs of a Two-Player Cooperative Game (Capacity Ratio 1 : 3)

	Non-cooperation	*Cooperation*
L_1	100,000 × (2,000 1,000) = US$ 100,000,000	[100,000 × (2,000 1,000)+100,000 × (2,000 1,000)+ 50,000 × (3,800-1,800)] × $\frac{1}{1+3}$ = US$ 75,000,000
L_2	100,000 × (2,000 1,000) = US$ 100,000,000	[100,000 × (2,000 1,000)+100,000 × (2,000 1,000)+ 50,000 × (3,800-1,800)] × $\frac{3}{1+3}$ = US$ 225,000,000

Here:

$$U(L_1) = \text{US\$ } 100{,}000{,}000 \ (> \text{US\$ } 75{,}000{,}000)$$
$$U(L_2) = \text{US\$ } 100{,}000\ 000 \ (< \text{US\$ } 225{,}000{,}000)$$

In this case, L_1 will refuse to cooperate with L_2 if L_1 can successfully predict the payoffs before forming the cooperation or L_1 will quit the alliance eventually after a certain period of cooperation because L_1 can be better off by adopting the go-it-alone’ policy.

An example of successful cooperation of two liners is the case of Maersk and Sea-Land. Maersk believed that its alliance with Sea-Land provided an effective tool to reduce costs and rationalise asset usage. Maersk’s profits in 1996 rose 23% to US$ 349 million. According to a recent study (Brooks, 2000), Sea-Land viewed its alliance with Maersk as a centrepiece of its strategy. In 1996, their operating income increased by US$ 80 million to US$ 318 million despite the situation of declining market rates.

4.2 Cooperative Game with more than Two Players

In general, cooperative game attaches more importance to the game’ with more than two players. The binding agreements between players amount to 2^n for an n-player game (Cruiel, 1997). Players in different coalition will get different payoffs. What follows is an example of a three-player cooperative game.

Suppose there are 3 liners in a market, L_1, L_2 and L_3. For simplicity, it is also supposed that the only goal for the liners is to pursue maximum payoffs. The minimum payoffs they can guarantee themselves are 20,000, 30,000, and 60,000 respectively if they serve the market with the go-it-alone' policy. The strategic alliances of L_1 and L_2, L_1 and L_3, and L_2 and L_3 can guarantee their minimum payoffs 70,000, 180,000, 300,000 to each coalition respectively. Finally the strategic alliance formed by L_1, L_2 and L_3 can achieve at least 500,000. Their characteristic functions are shown in Table 5.

Table 5. An Example of a Three-Player Cooperative Game

Coalition	*U*(Coalition)	Coalition	*U*(Coalition)
(L_1)	20,000	(L_1, L_3)	180,000
(L_2)	30,000	(L_2, L_3)	300,000
(L_3)	60,000	(L_1, L_2, L_3)	500,000
(L_1, L_2)	70,000	(ϕ)	0

According to the definition of core, a 3-tuple (x_1, x_2, x_3) is an imputation in the core if and only if

$$x_1 \geq 20{,}000$$
$$x_2 \geq 30{,}000$$
$$x_3 \geq 60{,}000$$
$$x_1 + x_2 \geq 70{,}000$$
$$x_1 + x_3 \geq 180{,}000$$
$$x_2 + x_3 \geq 300{,}000$$
$$x_1 + x_2 + x_3 = 500{,}000$$

All solutions satisfying the above constraints constitute the core. No one can get better payoff by his own effort in a rational distribution defined by core. For example, according to the ratio of the capacities of liners and the revenue, the payoffs to three liners are 100,000; 200,000 and 200,000 respectively, there is no way for one liner to enlarge his payoff given the others stick to their strategies.

The solutions out of the core are, however, rather unstable. Suppose the two situations:

Situation 1 L_1 and L_2 constitute a coalition and L_3 adopts the go-it-alone' policy
Situation 2 L_1 is discarded from the coalition of L_1 and L_2, and L_2 and L_3 constitute a new coalition

According to the definition of the core, for situation 1, we have:

$$x_1 \geq 20{,}000$$
$$x_2 \geq 30{,}000$$
$$x_1 + x_2 = 70{,}000$$
$$x_3 = 60{,}000$$

For situation 2, we have:

$$x_2 \geq 30{,}000$$
$$x_3 \geq 60{,}000$$
$$x_2 + x_3 = 300{,}000$$
$$x_1 = 20{,}000$$

Compare the payoffs of L_2 and L_3 in two different situations. L_2's payoff in situation 1 ranges from 30,000 to 50,000, while 30,000 to 240,000 in situation 2; while L_3's change from 60,000 in situation 1 to between 60,000 and 270,000 in situation 2. So L_2 and L_3 would possibly like to cooperate with each other to get the better payoff. This is another reason why the shipping alliances tend to be unstable.

A vivid example to validate the above theory lies in the transfer of OOCL from Global alliance to Grand Alliance in 1997. According to the corporate manager of OOCL (Fossey, 1998):

> The deal (transfer) gives his company more service options and enhanced operating efficiency than that available with the Global Alliance. In particular, the Hong Kong-based line benefits from a direct all-water link between Asia and US East Coast (USEC) via the Suez Canal and direct calls at Mediterranean ports."

4.3 The Existence of the Core

The above discussion shows that the solutions out of the core are unstable; hence it is natural for liners to move into a stable and satisfactory area, that is, the core. Unfortunately, the core of shipping market does not always exist (e.g. Button, 1999). A simple example of cooperative game without core is shown in Table 6, which is a slightly revised version of Table 5.

Table 6. An Example of a Three-Player Cooperative Game without the Core

Coalition	*U*(Coalition)	Coalition	*U*(Coalition)
(L_1)	20,000	(L_1, L_3)	400,000
(L_2)	30,000	(L_2, L_3)	440,000
(L_3)	60,000	(L_1, L_2, L_3)	500,000
(L_1, L_2)	380,000	(ϕ)	0

The same formula aiming to get the core can be developed as follows:

$$x_1 \geq 20{,}000$$
$$x_2 \geq 30{,}000$$
$$x_3 \geq 60{,}000$$
$$x_1 + x_2 \geq 380{,}000$$
$$x_1 + x_3 \geq 400{,}000$$
$$x_2 + x_3 \geq 440{,}000$$
$$x_1 + x_2 + x_3 = 500{,}000$$

It is easy to find that there is no solution meeting the above conditions at the same time, which means that there is an empty core under such conditions. Compared Table 6 with Table 5, obviously, the changes of minimum payoffs which can be guaranteed to achieve by the coalitions of (L_1, L_2), (L_1, L_3) and (L_2, L_3) lead to the empty core. In practice, these changes may be reflected by the fluctuations of shipping demand usually influenced by seasonality, politics or other external events. In fact, it goes without saying that these changes are unavoidable in shipping industry, which implies that it is quite difficult to achieve the stable shipping alliance in practice given the frequent fluctuation of shipping market.

4.4 Discussion

As stated in section 2, the objectives to form shipping cooperation, the causes leading to the instability and the failure of shipping alliance are complicated problems related to not only economic benefits of the liner companies but also the long-run plans of the liner companies, the great change of the characteristics of container ships, the constraints of shipping policy, etc. In other words, the strategic alliance is a multiple dimensional problem. However, the cooperative game theory is mainly concerned with a single dimension (i.e. mainly on economy or politics and this paper deals with the revenue of liners). Consequently it seems to be beyond the capability of cooperative game theory to fully explain the multiple strategic issues of shipping cooperation.

The cooperative game theory mainly studies the quantified' problem such as the distribution of payoffs, which leads to another drawback in the application of cooperative game theory to shipping cooperation, that is, some factors influencing the shipping cooperation, such as the objectives to form the strategic shipping alliances and the causes leading to the instability or failure of the shipping operation, cannot be quantified. For example, The market share of conference operators has been declining steadily in the past two decades because of the anti-trust laws in the US and Europe (Stopford, 1997; Brooks, 2000). In fact, this influence cannot be converted into dollars. Although these non-qualified factors may rank as highly as economic benefits in terms of their impact on strategic shipping alliances, it is quite difficult to build them into the cooperative game framework.

In spite of the inherent drawbacks of the application of cooperative game theory to this area, however, this paper is of its practical significance. Since pursuing the economic benefits is almost all the time the most important factor to be considered by liner companies, our application of cooperative game theory is successful in identifying the relationship between the shipping cooperation and the fluctuation of shipping demand from an economic viewpoint. In fact, this approach can be extended to analyse the relationship between the shipping cooperation and many other influential factors in shipping market such as the freight rates and running costs of liners. The similar conclusion can be reached that the fluctuations of these factors will possibly destroy the stability of shipping cooperation in case that liners attach great importance to their revenues.

5. CONCLUDING REMARKS AND FURTHER RESEARCH AREAS

Cooperation between lines has been a hot issue since the advent of liner services and containerisation. The current forms of shipping cooperation including shipping alliances, shipping consortia and mergers and acquisitions (M&As) shows the complexity of this segment of shipping market. Such cooperation is implemented in a various way and has, to some extent, overlapping and varying characteristics. Some liners achieve great success by cooperation compared with those failed from it. Furthermore, apart from the extensive cooperation, some liners who adopt the 'go-it-alone' policy may also show good economic performance.

Thus, to derive the common essence from this complicated market makes it tractable; this paper applies the theoretical tenets of cooperative game theory to the liner shipping market. The core is a vital concept in cooperative game theory and it is indeed the best payoff to each player in all of the worst situations; it is '*the territory over which the coalitions do battle*' (Shubik, 1982) This is of significance to players because, if they know at least what they are able to get, then they will improve their payoff based on that in reality. It can be claimed that the liner shipping market has been well explained by the core theory.

The main difference between cooperative and non-cooperative game is that the former focuses on distribution of payoffs among players while the latter studies what the player should do according to the strategies of other players and his own situation. (Aumann, 1997). Liner shipping market is a dynamic industry. In order to agree on targets and set implementation priorities, not only must the individual partner's current capabilities be assessed but also their potential joint capabilities, as well as the possibility of utilising third parties. At each stage of the analysis and of planning for implementation, the alliance will meet with internal barriers and resistance. In this respect, non-cooperative game theory empirically proves a powerful tool to analyse a strategy liners should adopt.

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