Routledge
Taylor & Francis Group

TECHNOLOGICAL AND ECONOMIC DEVELOPMENT OF ECONOMY
ISSN 2029-4913 print/ISSN 2029-4921 online

2011 Volume 17(3): 445–458
doi:10.3846/20294913.2011.580578

CONTRIBUTION-BASED PROFIT-SHARING SCHEME FOR JOINT VENTURES

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Received 07 July 2009; accepted 28 June 2010

Abstract. Along with globalization of the construction market, international construction firms often choose to cooperate with local construction firms in the form of Joint Ventures (JV) when they enter into the domestic markets of different countries. In this way, they cannot only reduce investment risks, but also enhance production efficiency, reduce costs and generate more profits. The conventional method of profit-sharing between JV firms is based on ratio of investment. However, as the firms make different contributions to the project, the rationality of such a profit-sharing method is often doubtful and thus is difficult to maintain a stable cooperative relationship for a JV team. Based on the concept of the cooperative game theory, this paper proposes a contribution-based profit-sharing model using Shapley Value. A case study is used to describe how firms can use this model to reach decisions of participation, and determine a fair profit-sharing rule after cooperation to enhance mutual trust and create the advantages of cooperation.

Keywords: profit-sharing, joint venture, cooperation, strategic alliance, game theory, Shapley value.

Reference to this paper should be made as follows: Hsueh, S.-L.; Yan, M.-R. 2011. Contribution-based profit-sharing scheme for joint ventures, *Technological and Economic Development of Economy* 17(3): 445–458.

JEL Classification: C51, C68, C71, D24, L74.

1. Introduction

The construction industry is characterized by sporadic projects and fierce competition (Cheng *et al.* 2001). Stepping into the globalization era, the construction industry will face a more severe business environment. Joint Venture (JV) is considered, by international construction firms, one of the most efficient methods of reducing financial risks (Bing *et al.* 1999a; Bing *et al.* 1999b). Today, in order to build competitiveness, construction firms may want to reduce costs and increase profits through coalitions (Proverbs, Holt 2000), while the established cost advantage can also bring more market opportunities to the participants (Lo *et al.* 2007). In addition, a strong coalition can enhance the team qualification, which is especially important for projects delivered by qualification-based selection system (Lo, Yan 2009). However, previous studies have indicated that construction firms are mainly provisional contracting organizations and thus are difficult to establish a long-term cooperative relationship (Koskela 2003; Wegelius-Lehtonen 2001). Moreover, large-scale companies may have a manipulative mind-set, which often causes profit-sharing problems adverse to benefit sharing. Such a partnership will lead to mistrust between the cooperating parties (McIvor 2001). Hence, it is difficult to realize coalition (Owen 1995) when there are unfair and inappropriate profit-sharing modes within the competitor partnerships unable to meet their expected profit.

To form a JV team, companies have to select partner(s), assign each party's work scope, and especially, negotiate the sharing of profits, which is usually done by arranging separate amounts of the expected total profits or by sharing proportionally, depending on the collaborating relationships among the JV team. However, since each JV party is pursuing its maximum profits, the conflicts of interest make the sharing of profits always a challenging task (Yan 2011). Conventionally, construction JV firms will negotiate their individual work range and ratio of investment before a cooperative agreement is reached, and then distribute the profits based on the ratio of investment. As such a profit-sharing mode only considers the capitals invested by the cooperative firms, and neglects other contributions of the individual firms to the project, the firm possessing core competence and contribution may often be dissatisfied with the profit-sharing. Although JV may bring benefits to the cooperative firms in different degrees, such as costs reduction (Proverbs, Holt 2000), financial advantages, information sharing (Simchi-Levi *et al.* 2001), resource complementation (Nicolini 2001), etc., there are few cases of long-term relationships between the cooperative firms in practice. The main reason is that the JV participators have not found an equilibrium point of interest distribution in the partnership. If the profit generated through JVs can meet the expectations of all participators, and the profit gained by each participator is higher than independent contracting, the firms will all be willing to participate in the JV. Meanwhile, both parties can gain better beneficial results through mutual sharing of helpful resources (Dainty *et al.* 2001).

This paper will initially review costs advantages and profit-sharing issues of JV firms, and then use cooperative game theory and Shapley Value to propose a model to calculate profit-sharing of construction joint ventures. Construction firms can use this profit-sharing model as an important negotiation basis in selecting JV partners. At the end, a case study is conducted to describe how a foreign construction firm and a local construction company achieve a successful partnership, earning higher profits for both parties than independent contracting, even though their profit-sharing is not based on ratio of investment.

2. Production costs and profits of JV

While selecting appropriate and good firm for JVs can reduce investment risk and escalate work efficiency, it is also crucial to make accurate estimation upon cost and gained profit comparing independent with JVs before cooperation (Hsueh *et al.* 2007).

In independent operations, the profit of individual contractor is shown in Eq. (1). Based on the cost structure and work items, the total cost of a project can be divided into many costs for sub-work items. However, in a coalition, the profit of the coalition can be increased by combining the specialties of the coalition members. Coalition between construction firms can obviously help enhance market competitiveness and reduce costs. The cost function of a coalition is shown as Eq. (2).

$$V_i = C_a - \sum_{j=1}^{n} C_{ij} , \quad (1)$$

$$V_c = C_a - \sum_{j=1}^{n} \min C_{cj} , \quad (2)$$

C_a = total project contract amount,

V_i = total profit of contractor *i*,

C_{ij} = contractor *i*'s cost of work item *j*,

V_c = total profit of coalition,

$min\ C_{cj}$ = the minimum cost of work item *j*.

Eq. (2) demonstrates the possibility to reduce project cost by a proper coalition. For example, if a foreign firm with high technological capacity cooperates with a local firm, the cost advantages of both parties can be integrated to reduce total project costs.

Foreign construction firms possess affluent capital, technology, and large-scale construction equipments, and are therefore, advantageously positioned for projects requiring high-level technology. However, as foreign construction firms are usually not familiar with local environments, they will face higher costs in acquisition of human resources. In addition, their administrative and marketing costs will be high due to unstable project sources. The projects contracted by local construction firms are usually of lower technological levels. Most local firms lack high-level engineering staff and equipment, and will pay a higher cost when contracting projects of higher technological levels. Hence, they seldom contract such projects.

Local construction firms can promote business volume and reduce costs through coalition. Independent operating construction firms have less project sources due to capital limitations and qualification limits for bidding on some construction projects. As mentioned above, foreign construction firms can provide local firms with professional technology and equipment, and local firms are relatively familiar with local operation rules and can provide foreign firms with adequate human resources. Through JV, foreign firms can reduce indirect costs and increase bidding opportunities in local construction markets. In addition, local firms can save a large sum of expenditures on equipment and enhance their technological level to some degree.

3. Cooperative Games in JVs

It would be unfair especially for the party possessing with high technology and pose the barrier on a cooperative relationship, if the profit-sharing is set according to the proportion of capital invested. From the perspective of cooperative game theory, JVs take not only capital but also proficiency into consideration when distributing profit (Ferrero *et al.* 1997; Jia, Yokoyama 2003). Though the party with higher level of technology may have better profit-sharing, the profit gained through JVs is higher than independent construction pattern.

There are applications of game theory in construction industry. Ho (2005) modeled a bid compensation process as a non-cooperate static game to develop appropriate bid compensation strategies for project owners. Construction claims and financial renegotiation in PPP (public-private partnership) projects were approached as a dynamic non-cooperate game (Ho, Liu 2004; Ho 2007). Negotiations between BOT participants as well as risk allocations are also analyzed by game theory (Medda 2007; Shen *et al.* 2007). Studies in cooperative game are limited in collaborating formwork subcontractor (Perng *et al.* 2005) and subcontractors cooperation in time (Asgari, Afshar 2008). Few studies have been drawn on the construction JVs by using cooperative-game-theory approach.

3.1. Cooperative Game Theory

Game, refers to a confrontation state in which two, or more, players pursue their respective goals (Rasmusen 2001). The actions taken by the players to reach their goals are called strategy. The result of strategy implementation is called the payoff (Kreps 1990). The three factors to constitute a game are players, strategy, and payoff. In a game, in order to maximize their interest, the players may choose to compete or cooperate. The players will most often choose a method that is most advantageous to them. In the game theory, the game is divided into two forms: cooperative game and non-cooperative game. In a non-cooperative game, the players pursue their individual interest and choose their own strategy, and in deciding their own strategy, the players will often consider other players (Owen 1995). In a cooperative game, the players pursue a common goal to maximize the interest of the team under certain constraint conditions of the game. If the cooperation cannot generate a good result, the players will choose not to participate in the game. To form a cooperative game, the interest distribution between the players must meet the following two criteria:

1. Aggregation of the interest distributed to each player must be equal to the interest gained by the coalition formed by all the players.
2. The interest obtained by each player after participating in the coalition must not be less than the interest obtained in previous independent operations.

In the game theory, how to obtain an equilibrium strategy is regarded as a problem of the cooperative game in the form of coalition (or in a general form), such as the strategic coalition between a local construction firm and a foreign firm. When participating in the bidding for a project, the construction firm will choose operation modes based on evaluation of its own profitability. If the firm can obtain more profit through coalition to reduce total coalition costs, it is possible to form the coalition, and consequently the participants can share the profit in a proper interest distribution method. The premise of a cooperative game is mutual trust between the players and common pursuance of maximum group interest.

3.2. The Shapley Value

Shapley Value is an important topic in the cooperative game theory. It is the expected marginal amount contributed by a player to a coalition (Shapley 1953). Thus, the concept of Shapley Value can be used for sharing profit of JV projects based on the contributions of each JV participant. By using Shapley Value, the interest obtained after cooperation can be fairly shared. The distribution model is based on the following three axioms (Shapley 1953):

Axiom 1, axiom of symmetry. The rewards of each player is only in influenced by its contribution to the game, and not affected by its own preference or status.

Axiom 2, axiom of efficiency. The rewards generated by the game must be completely distributed to all the players.

Axiom 3, axiom of aggregation. If a player is simultaneously presented in two games, the rewards of this player are the aggregation of its rewards obtained from both games.

For each participator *i*, the Shapley Value calculates the aggregation of the contributions made by *i* to all the coalitions, as shown in Eq. (3):

$$\varphi_i = \sum_{S \subseteq N} \frac{(s-1)!(n-s)!}{n!} \{v(S) - v(S - \{i\})\}, \tag{3}$$

φ_i is the Shapley Value of participator *i*, and is the aggregation of the contributions made by *i* to all the coalitions in which it may be present.

N represents the set of all the members that may participate in the cooperative game, and the number of elements included is *n*.

S is the cooperative coalition, including member *i*, and is a subset of *N*. The number of elements included in *S* is *s*.

v is the profit gained by a coalition made up of multiple players, and *v*(*S*) is the maximum possible profit gained by *S* coalition.

v(*S*-{*i*}) is the maximum possible profit gained by *S* coalition, not including member *i*.

$\frac{(s-1)!(n-s)!}{n!}$ represents the possibility of *i* joining the *S*-{*i*} coalition.

In the circumstance of JVs, the coalition formed is two construction firms T{1, 2 }. V(1) represents the profit gained when the first firm (P1) contracts the construction project independently, V(2) represents the profit gained when the second firm (P2) contracts the construction project independently, V(12) represents the profit gained when the two firms cooperate in the form of a JV in contracting the project, and V(φ) represents the profit when the firms do not contract the project.

Hence, according to the definition of Shapley Value, the reward of P1 (φ 1) in the coalition is: φ 1 = 1/2{ V(1) – V(φ)} + 1/2{ V(12) – V(2)} }; The reward of P2 (φ 2) is: φ 2 = 1/2{ V(2) – V(φ)} + 1/2{ V(12) – V(1)}.

4. Case Study

The majority of construction projects in Taiwan are located in western areas, and local development of construction in eastern areas has been slow for decades. In order to promote industrial and economic development in eastern areas, the Taiwanese government began construction of the "National Su Hwa Highway" in 2003, to be constructed concurrently with both the West Taiwan Highway and Expressway Network to form a complete highway network around Taiwan, and realize the government goal of balancing local construction development. The planned "National Su Hwa Highway" is 102 kilometers long and the project costs are as high as NT$178.7 billion, with an investment scale second only to the national high-speed railway plan in Taiwan. As East Taiwan is mountainous, most projects are tunnelling works. Due to lack of technology in tunnelling works, the local construction firms in Taiwan must cooperate with foreign firms in the form of JVs.

This section uses the case of cooperation between a medium-sized Taiwanese construction firm and a Japanese construction firm to illustrate how a foreign firm uses the Shapley Value to evaluate and select a local partner when attempting to enter the local market and to reach an agreement on profit-sharing with the partner.

4.1. Background of the JV project

The project, in which both foreign and local firms are engaged in a JV team, is "No. 9 Tunnelling Project Southern Section". The length of the tunnel is 5.5 kilometers, and the contract amount is NT$3,229 million. In line with the agreement between the cooperative firms in forming for a JV project in order to reduce production costs and indirect overhead costs, the project is divided into civil work and main tunnelling work. The local firm is mainly responsible for the civil work and the foreign firm is mainly responsible for the tunnelling work. Details of the JV project are shown in Table 1.

Table 1. Basic information of the JV project

Differentiation		Foreign Firm	Local Firm
Project characteristics	Project type	Tunnelling project	
	Tunnel length	5.5 kilometers	
	Contract amount	NT$3,229,000,000	
	Ratio of investment	60%	40%
	Equipment	Large-scale equipment, i.e. shield machines (Transportation)	Small and medium – scale construction equipment
	Project team members	4 persons	20 persons
Remark	* Funds for the project are partly contributed by both parties and partly loaned from banks. * Costs of bank loans are interest rates. * Funds for the project include all expenditures to be paid in cash, such as wages and sub-construction amounts.		

4.2. Evaluation and selection of partner

There are two local construction firms, who want to cooperate with a foreign firm specializing in tunnelling work. One is a medium-scale construction firm (local firm A) and the other is a large-scale construction firm (local firm B). Before the cooperation, each of the three firms had evaluated the feasibility and costs of contracting the project independently. The estimated project costs are shown in Table 2 and the estimated profits are determined based on Eq. (1). The foreign firm is a specialized constructor in the aspect of tunnelling work who can directly send technical staff and equipment to Taiwan, and therefore the engineering costs for the tunnelling work is low. However, as the foreign firm is not familiar with the local environment, it faces relatively high production costs for the civil work, which requires relatively more local human resources. Its indirect costs are also high. The local firms are characterized by low costs for civil work and low indirect costs. However, if they assume the tunnelling work independently, they will have to pay large sums of expenditures to purchase or lease extra equipment. Meanwhile, the local large-scale firm is more advantageous than the medium-scale firm in the aspect of technology and has lower direct costs but faces higher indirect costs due to the larger scale of the company.

Overall, the foreign firm estimated a project cost of NT$3,108.76 million if it contracts the project independently, the local large-scale firm estimated a project cost of NT$3,134.78 million, while the local medium-scale firm estimated a project cost of NT$3,234.58 million which would induce a loss of NT$5.58 million.

To make the project become more profitable, each firm is seeking a cooperative plan to increase profit. Hence, after evaluation, it is believed that the total project costs will be lower if the foreign firm cooperates with a local firm in the form of a JV to contract the project. The foreign firm can take the specific responsibility of tunnelling works, and all civil works and project management tasks can be assigned to the local firm. Although there may be some extra costs for coordination and integration between the two parties, the total costs can still be lower than independent operations.

The foreign firm wants to select one local construction firm as its partner and therefore evaluated the costs, after cooperation, with each local construction firm. Based on the individual estimated project costs in Table 2, the estimated project cost for each JV team can be determined (see Table 3). Since individual firms have relative low costs in handling at least one of the project tasks (civil work, tunnelling, or administration work), the work division of a JV team would naturally be based on the relative costs of specific tasks. For example, for foreign-local firm A JV team, the best work division of foreign firm is to handle tunnelling work and rely on the local firm for civil work and administration works. Thus, the estimated total project cost for the JV team would be the costs for tunnelling of foreign firm and the civil work and indirect costs of local firm, plus certain transaction cost (10%). According to the principle, the estimated project cost for each joint venture team can be determined.

The evaluation results show that, the total costs can be reduced to NT$3,053.69 million and a profit of NT$175.31 million if it cooperates with the local medium-scale firm, while the total costs can be reduced to NT$3,011.02 million and a profit of NT$ 217.98 million if it cooperates with the large-scale firm. However, the total project profit is only a general reference for cooperation, the profit amount distributed to each firm must be further calculated in order to determine which cooperative plan is better for both parties.

Table 2. Estimated cost of independent operations

Contract amount		322900					Unit: NT$10,000		
	Foreign firm			Local firm A			Local firm B		
Pricing Stage	Costs for civil work	Costs for tun-nelling	Indirect costs	Costs for civil work	Costs for tunnelling	Indirect costs	Costs for civil work	Costs for tunnelling	Indirect costs
1	3925	6725	4894	3525	9018	3630	2984	8713	3977
2	9420	16140	11745	8461	21642	8712	7162	20910	9546
3	14915	25556	18596	13396	34267	13794	11339	33108	15114
4	17270	29591	21532	15512	39678	15972	13130	38335	17500
5	16485	28246	20553	14806	37874	15246	12533	36593	16705
6	11775	20175	14681	10576	27053	10890	8952	26138	11932
7	4710	8070	5872	4230	10821	4356	3581	10455	4773
Sum	78500	134503	97873	70507	180353	72598	59680	174252	79546
Total Costs			310876			323458			313478
Estimated Profit			12024			–558			9422

Table 3. Estimated project costs after cooperation

Contract amount			**322900**			**Unit: NT$10,000**
Pricing Stage	**Foreign firm + Local firm A**			**Foreign firm + Local firm B**		
	Costs for civil work	**Costs for tunnelling**	**Indirect costs**	**Costs for civil work**	**Costs for tunnelling**	**Indirect costs**
1	3878	7398	3993	3282	7398	4375
2	9307	17754	9583	7878	17754	10500
3	14736	28111	15173	12473	28111	16625
4	17063	32550	17569	14443	32550	19250
5	16287	31070	16770	13786	31070	18375
6	11634	22193	11978	9847	22193	13125
7	4653	8877	4791	3939	8877	5250
Sum	77558	147953	79858	65648	147953	87501
Total Costs		305369			301102	
Estimated Profit		17531			21798	

The profit distributed to each firm is calculated based on the concept of Shapley Value (see Table 4). In the first coalition, as the local firm may make a loss if it contracts the project independently, the profit is considered as zero. Hence, based on Eq. (3), the profit allocated to the foreign firm is 1/2(12024) + 1/2(17531 – 0) = 147.77 million, while the profit allocated to the local firm is 1/2(0) + 1/2(17531 − 12024) = 27.54 million.

In the second coalition, the profit allocated to the foreign firm is 1/2(12024) + 1/2(21798 – 9422) = 122 million, while the profit allocated to the local firm is 1/2(9422) + 1/2(21798 – 12024) = 95.98 million.

Table 4. Comparison of different coalitions

Contractor	**Contract amount**	**Total cost**	**Estimated profit**	**Shared profit by the foreign firm (based on contribution)**	**Shared profit by the local firm (based on contribution)**
Foreign firm	322900	310876	12024		
Local firm A	322900	323458	–558		
Local firm B	322900	313478	9422		
Foreign + Local firm A	322900	305369	17531	14777	2754
Foreign + Local firm B	322900	301102	21798	12200	9598
Unit: NT$10,000					

The results show that the foreign firm will obtain higher profit if it participates in the first coalition. Hence, the foreign firm has an incentive to cooperate with the local medium-scale construction firm.

4.3. Evaluation of the profit-sharing method

Based on the information gathered by the JV team and the bid evaluation, the coalition of the foreign firm and the local medium-scale firm could win the contract for this project at a price of NT$3,229 million. Pricing of this project is divided into 7 milestones. The project costs borne by each party based on ratio of investment are shown in Table 5, and the accumulated costs for the project are shown in Fig. 1.

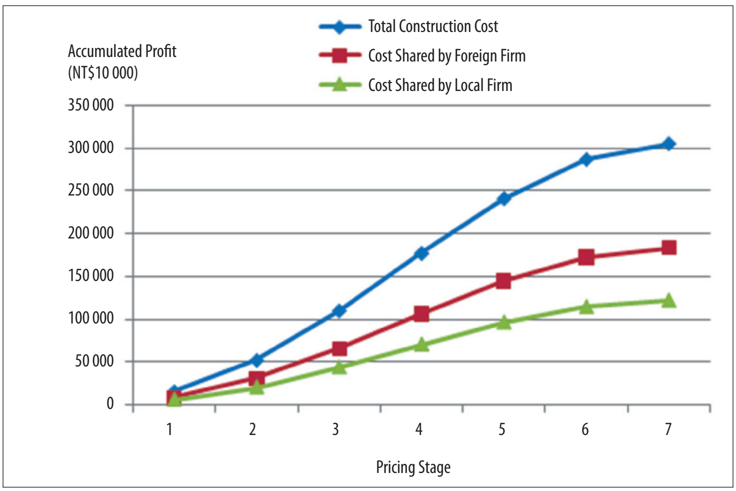

Fig. 1. The project accumulated costs

For the profits generated after the cooperation, a comparison is made between the distribution method based on ratio of investment and the proposed method (see Table 6). Fig. 2 shows the profits "distributed based on ratio of investment", "distributed based on Shapley method", and generated from "independent contracting" for comparison. As for distribution of profit in cooperation, the local firm, will gain more profit if the distribution is based on ratio of investment. For the foreign firm, however, the profit gained is even lower than independent contracting in spite of the risk of losing the contract after coalition. Hence, this JV plan is not attractive to the foreign firm. Relatively, if the profit is distributed based on the proposed method, the foreign firm will gain more profit than independent contracting and thus the plan becomes attractive. On the other side, the local firm still can benefit from the cooperation with the foreign firm and obtain a reasonable profit, while the local firm might face a certain loss if contracting independently. In conclusion, comparison of the profits distributed to the foreign firm and the local firm based on the proposed method and the profits generated from independent contracting, indicates a profit increase of NT$27.53 million for the foreign firm, and an increase of NT$33.12 million for the local firm. The closeness of increased profits for both parties demonstrates that the proposed method is more fair, rational, and feasible than the traditional distribution method based on ratio of investment.

Table 5. Cost estimation for the JV team

Contract amount			322900		Unit: NT$10,000	
Stage	Foreign firm (60%)		Local firm A (40%)		Foreign firm +Local firm A (100%)	
	Costs	Accumulated costs	Costs	Accumulated costs	Costs	Accumulated costs
1	9161	9161	6107	6108	15269	15269
2	21987	31148	14658	20766	36644	51913
3	34812	65960	23208	43974	58020	109933
4	40309	106269	26872	70846	67181	177114
5	38476	144745	25651	96497	64127	241241
6	27483	172228	18322	114819	45806	287047
7	10993	183221	7329	122148	18322	305369

Table 6. Comparison of different profit-sharing

Differentiation	Independent contracting	Profit distribution based on ratio of investment			Profit distribution based on profit contribution	
	Profit	Ratio	Profit shared	Profit shared: compared with independent contracting	Profit shared	Profit shared: compared with independent contracting
Foreign firm	12024	60%	10519	−1505	14777	+2753
Local firm	−558	40%	7012	+7570	2754	+3312
Re-marks	The foreign firm got 12024 and local firm got −558 when each of them invested alone without cooperation. In cooperation, it is unfair to distribute the profit according to the proportion of investment and it is also not easy to reach agreement. If the profit is shared based on the proportion of investment, the foreign firm will have no incentive to cooperate with the local firm, while he got less profit than independent contracting. Based on the contribution-based profit distribution upon JV, both parties gained higher profit than individual sole investment and thus the JV can be more successful. Unit: NT$10,000					

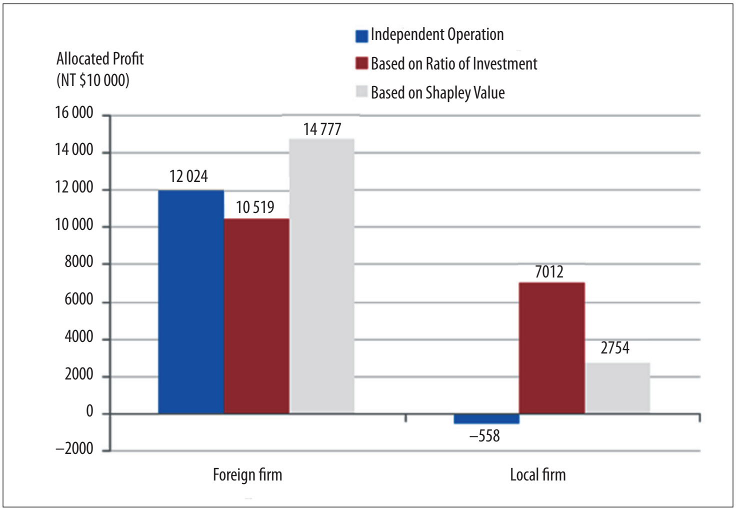

Fig. 2. Comparison of construction firm's profit under different situations

5. Conclusions

Through coalition of JV, the construction firms can share professional technologies and resources and increase sources of new contracts by breaking through the bidding thresholds. The foreign firm can save indirect costs, while the local firm can avoid capital tied-up by saving a large sum of expenditures on equipment, and, to some degree, enhance its technological level. A win-win opportunity is thus created.

For a commercial perspective, a successful JV ensures all the participants to obtain more profits than performing the work individually. However, the traditional profit-sharing merely based on the ratio of investment might not satisfy all the JV participants in some cases. This paper proposes a profit-sharing model based on the cooperative game theory to make up for the deficiency of the traditional profit-sharing method and promote the relationship between JV firms. In the end, the case study shows that, the contribution-based profit-sharing model can ensure all the JV participants to obtain a profit more than their independent works. Thus, the proposed model can be used for supporting the partner evaluation and selection decisions, which facilitate construction companies to choose the most appropriate JV partners through prior profit calculation and find a profit-sharing solution acceptable to both parties. More successful JVs might be formed with the innovative solution to the conventional problems of profit-sharing.

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PELNO PASIDALIJIMO TARP ĮMONIŲ SCHEMA, PAGRĮSTA PATIRTOMIS IŠLAIDOMIS

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Santrauka. Vykstant statybos rinkos globalizacijai, tarptautinės statybos įmonės, patekusios į vietinę kitos šalies rinką, dažnai linkusios bendradarbiauti su vietos statybos įmonėmis. Jos gali ne tik sumažinti investicijos riziką, bet ir padidinti gamybos efektyvumą, sumažinti išlaidas ir gauti didesnį pelną. Tradicinis pelno pasidalijimo metodas tarp įmonių grindžiamas investicijų santykiu. Tačiau kai įmonių įnašas į projektą skirtingas, toks pelno metodo racionalumas dažnai abejotinas, todėl tokiu atveju yra sunku palaikyti stabilų įmonių bendradarbiavimą. Remiantis lošimų teorijos koncepcija, šiame darbe siūlomas pelno pasidalijimo modelis naudojant Shapley reikšmę. Skaitmeniniu pavyzdžiu rodoma, kaip įmonės gali taikyti šį modelį priimdamos sprendimus dėl dalyvavimo bendroje veikloje ir teisingo pelno pasidalijimo. Taip sustiprinamas tarpusavio pasitikėjimas ir sukuriamos bendradarbiavimo prielaidos.

Reikšminiai žodžiai: pelno pasidalijimas, bendra įmonė, bendradarbiavimas, strateginis aljansas, lošimų teorija, Shapley vertė.

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