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CREATING RESEARCH INVENTIONS BY COMBINATION OF MULTIPLE THEORIES AND CONCEPTS: AN IMPLICATION FROM DEVELOPING A NEW MATHEMATICAL MODEL FOR CORPORATE ALLIANCES

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ABSTRACT

A mathematical model to express the mutual complementary relationship between two companies during the matching phase in a corporate alliance was developed recently. The model made possible the computational expression of the relationship as a value. The developers applied the methodology of modeling in cyber informatics of computer science to the research of corporate alliances. Additionally, the developers combined the theoretical framework of Resource-Based View (RBV) with the concept of flow in physics and the concept of Give and Take in psychological science. The combination of these theories and concepts lead to the successful construction of a brand new mathematical model. The model was implemented by programmatic means, which proved its validity. In this way, the combination of multiple theories and concepts has proven to be the key factor for creating new inventions in management studies. These days, research activities including the management field are becoming progressively mature, much more segmented, and increasingly specific. As a result of this, researchers tend to concentrate only on a single theory, framework or discipline. This trend obstructs the creation of new inventions in management studies. This paper asserts that the combination of multiple theories and concepts by importing them from other different scientific fields is significantly important and useful, and is a key to success for innovation in research activities.

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KEYWORDS*:* Mathematical Model, Corporate Alliance, Resource-Based View (RBV), Combination of Multiple Theories, Creation of Inventions

INTRODUCTION

This paper presents a new mathematical model for corporate alliances and imply how to create research inventions in management studies by combinations of multiple theories and concepts. The paper defines a corporate alliance as "The state in which two or more companies are independent, in order to develop new business or expand existing business by the exchange of complementary management resources provided to each company regardless of the presence or absence of a binding contract or capital relationship, with continued cooperation, to share the outcome." This definition is originally from Yoshino and Rangan (1995), which is the first comprehensive study on the different types, classes and definition of corporate alliances. A new mathematical model of mutually complementary for corporate alliances was proposed by Tomita and Takefuji (2015, 2016a, 2016b, 2016c, 2016d) and Tomita (2017). The mechanism of the formation in the matching phase of a corporate alliance between two companies can be implemented programmatically and computed as a value. In the development of the

model, the combination of Resource-Based View (RBV), the concept of flow in physics and the theory of Give and Take in human relations of psychology served as the main theory framework.

In the model, the success of a corporate alliance between two companies is increasingly more probable as the mutual complementary relationship, which is the exchange of strengths and weaknesses of each company, becomes increasingly stronger. The model has been constructed making use of a one-dimensional matrix, bipolar vector, and a distance from the maximum point on a two-dimensional map. The process of development of the model in this paper is used as a case study. The paper asserts that the combination of multiple theories and concepts by importing them from other different scientific fields is significantly important and useful, and is a key to success for innovation in research activities.

The organizational layout of this paper is as follows. The paper starts by reviewing past research on basic management theories such as Resource-Based View (RBV) or other useful concepts for development of the model like the concept of Give and Take in psychological sciences and flow in physics. From there I will outline the proposed mathematical model which expresses the relationship between two companies in a corporate alliance. Then, this paper explains the mechanism of corporate alliances using the terms of flow intensity and flow balance. Until the development of this model, the relationship of two companies in a corporate alliance could not be calculated as a number. However, by the combination of multiple concepts and theories, this model has been created and it is now possible to express the strength of a relationship as a numerical value. If we use the developed model, we can choose the most optimal alliance partners among multiple candidates and select pairs more likely to be successful among a large group of potential partner companies. This is the effectiveness of the model.

LITERATURE REVIEW

In relation to prior research on corporate alliances between two companies, the theoretical background was presented by Yasuda (2003, 2006, 2010, 2016). This theory relies primarily on Resource-Based Theory. Research on Resource Base View (RBV) has been performed in the alliance research from viewpoints including resource characteristics, alliance type, risk management in Das and Teng (1998) and Das and Teng (2000). In Lavie (2006), emphasis is placed on the relationship rather than the establishment of resources. As a genealogy of business science in alliance research, the fundamental theory used as the starting point is Resource-Based View (RBV) as presented by Wernerfelt (1984) and Barney (1991). As a development, Yasuda (2003, 2006, 2010, 2016) presents the idea that "An alliance is the exchange of management resources" as a new analytical approach to research on strategic alliances. Yasuda (2003, 2006, 2010, 2016) defines the resources owned by companies in a simplified manner as the five management resources of (1) technical resources, (2) human resources, (3) production capacity, (4) sales force, and (5) capital resources. It concludes that an alliance is the exchange of these five management resources.

In Tomita and Takefuji (2015, 2016a, 2016b, 2016c, 2016d) and Tomita (2017), the source of the competitive advantage of a company depends on internal management resources of the company, so in order to grasp the concept of an alliance being to acquire management resources, the main theoretical framework used for alliance research was resource-based theory. However, in these previous studies, there existed no mathematical model that expressed the relationship between the assumed candidate companies. For example, in Mitsuhashi and Greve (2009) research dealing with the matching stage of the alliance had not yet established a mathematical model. There was a mathematical matching model in the field of market design by Roth (2015), but it was not targeted for intercorporate alliances. Tomita and Takefuji (2015, 2016a, 2016b, 2016d) had for the first time in that area become the "white space" in this field of research by constructing a mutually complementary mathematical model expressing the relationship in an intercorporate alliance between companies during the matching phase. In Tomita and Takefuji (2016c) and Tomita (2017), additional mathematical models of mutual complementary, additive and synergistic alliances were proposed. The results of the extensive research in academic papers in the field of psychology

by Schaufeli (2006) reveal that it is the claim of over 8,000 professionals (teachers, doctors, nurses, police, prisoner security, social workers, mental disability workers) that the breakdown of the balance of Give and Take is the main cause of burnout.

That is, when a relationship is too far imbalanced or mismatched, it results in a Give and Take imbalance or otherwise lopsided or unfair situation for one party or the other, which in turn causes a breakdown in the relationship, known as burnout. In the scope of this paper, the imbalance and resulting burnout occurs when the gap between rewards and cost is too great. From this, we have taken the concepts of the social exchange theory of Give and Take as it pertains to personal relationships and used it in this study to construct a mathematical model for corporate alliances. Tomita and Takefuji (2016d) and Tomita (2017) incorporate the idea of social exchange theory of Give and Take, which has been studied in personal relationships, into the study of building a mathematical model of the alliance. Schumpeter (1912) said new knowledge is created by new combinations of already existing knowledge. This is prior important literature for this research.

OUTLINE OF PROPOSED MATHEMATICAL MODEL

Summary of the Mutually Complementary Mathematical Model for Corporate Alliances

The concept of a mutually complementary alliance model, revolves around the idea that strengths of company B will complement the weaknesses of company A, and vice versa. The strengths of company A complement the weaknesses of company B. The mutually complementary strength depends on the complements provided from one company to the other. If the compliments from one company or both are large, the mutually complementary strength will be large. That is, the mutually complementary relationship in a corporate alliance is a bipolar model based on the mutually attracting forces between two companies.Regarding the proposed mutual complementary mathematical model in Tomita and Takefuji (2015, 2016a, 2016b, 2016c, 2016d) and Tomita (2017), there will be an outline provided. In this paper, even though there will be explanations of the physical concept of flow and Give and Take as used in interpersonal relationships, prior to these explanations there will be an outline of the mutual complementary mathematical model.

Utilizing a One-Dimensional Matrix and Bipolar Vector to Express the Strengths and Weaknesses between Two Companies

The strengths and weaknesses of companies A and B can be expressed as a one-dimensional matrix of eight characteristics representing management resources, each graded with values between 1 and 5. The eight characteristics are mainly based on management resources. Also, the integer values represent the score evaluating the strength and weakness of these characteristics for each company. As an example, consider the two following companies,

Company A $a = (1, 5, 4, 2, 2, 1, 3, 5)$
Company B $b = (5, 1, 1, 3, 4, 2, 3, 2)$

From the above, the result "c" can be evaluated by subtracting the values of each of the characteristics of Company B from Company A in order to get a directional bipolar vector with values for each characteristic ranging from 0 to 4 (positive or negative). That is to say, we can express the mutually complementary relationship between two companies as a bipolar vector.

Company A – Company B
$c = a-b = (-4, 4, 3, -1, -2, -1, 0, 3)$

Summation of Plus and Minus Bipolar Vectors (Positive and Negative Integers)

As an example, in companies A and B mentioned previously, the value expressing the provided strengths from company A to company B is the summation of positive integers (plus' bipolar vector):

$4 + 3 + 3 = 10$

This number (10) shows the strengths of company A that complement the weaknesses of company B. Conversely, taking the summation of negative integers (minus' bipolar vector):

$-4 + (-1) + (-2) + (-1) = -8$

This number (-8) shows the strengths of company B that complement the weaknesses of company A. The two numbers (10, -8) show the mutually complementary relationship between company A and company B.

The Relationship Strength Mathematically Expressed as the Distance from the Maximum Point

The strengths of the mutually complimentary distance are expressed by measuring the distance from the largest mutually complimentary point of strength. Namely, in regards to the bipolar vector of the length from 0 to 4 of the eight characteristics, the maximum mutually complementary value determined from taking two sets of half the number of characteristics (4) with a maximum length of 4 for each, which is the longest possible bipolar vector bilaterally.

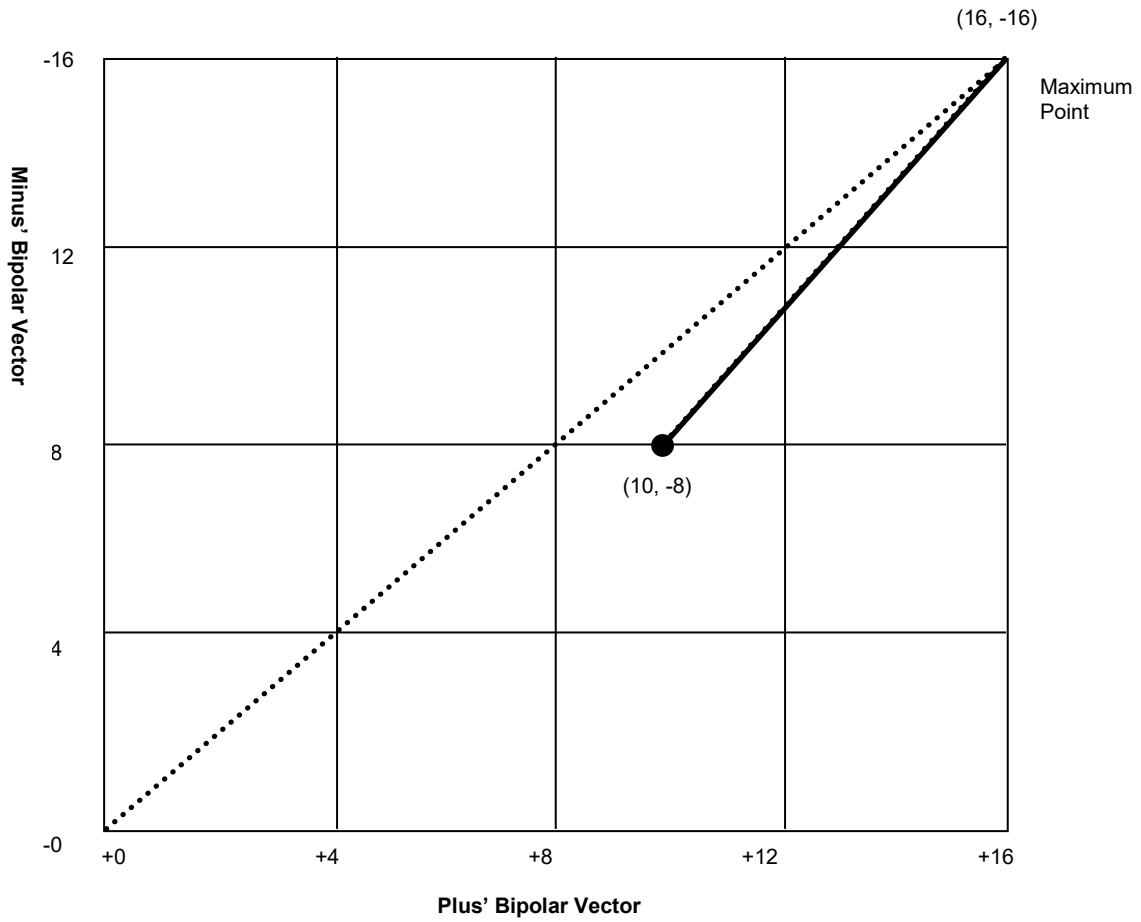
(8 characteristics / 2) * Maximum length of 4 = (16, -16)

The distance (d) between two points is calculated as follows:

$$d = \sqrt{(a_1 - a_2)^2 + (b_1 - b_2)^2}$$

The maximum value of the mutually complementary strength of (16,-16) is shown as the distance from (0, -0) to (16, -16), which is named the maximum point. The model expresses the strength of the mutually complementary relationship between two companies as a distance from the maximum point mathematically. When the distance from the maximum point is small, it indicates that the mutually complementary strength is strong. Since it is simpler to subtract from larger numbers, we have inverted the magnitudes of the values. For example, with a mutually complementary strength of (10, -8) for companies A and B, it is possible to calculate the distance from (16, -16) by means of subtraction from the maximum value as shown in Figure 1 below.

Figure 1: Mathematical Expression by the Distance from the Maximum Point



This figure shows the example representing the mutually complementary strength of two companies by the distance from the maximum value of the mutually complementary strength. In case of 8 characteristics, the maximum value of the mutually complementary strength is (16,-16) and the point presenting the mutually complementary strength of Company A and Company B is (10,-8).

Mutually Complementary Strength and the Related Coefficient as a Value

The mutually complementary strength derived and explained above can be expressed by the following formula:

$$\sqrt{2\times(\frac{4\times len(c)}{2})^2}-\sqrt{(\frac{4\times len(c)}{2}-Plus)^2+(\frac{-4\times len(c)}{2}-Minus)^2}$$

In the above formula, len(c) is the number of characteristics, Plus=Σ (positive integers), and Minus=Σ (negative integers). When this value is normalized to a value between zero and one it becomes easier to handle. The relative mutually complementary strength can be calculated from the following formula, and is here forth defined as the mutually complementary strength coefficient.

$$1-\frac{\sqrt{(\frac{4\times len(c)}{2}-Plus)^2+(\frac{-4\times len(c)}{2}-Minus)^2}}{\sqrt{(\frac{-4\times len(c)}{2})^2}}$$

In the above formula, len(c) is the number of characteristics, Plus=Σ (positive integers), and Minus=Σ (negative integers).

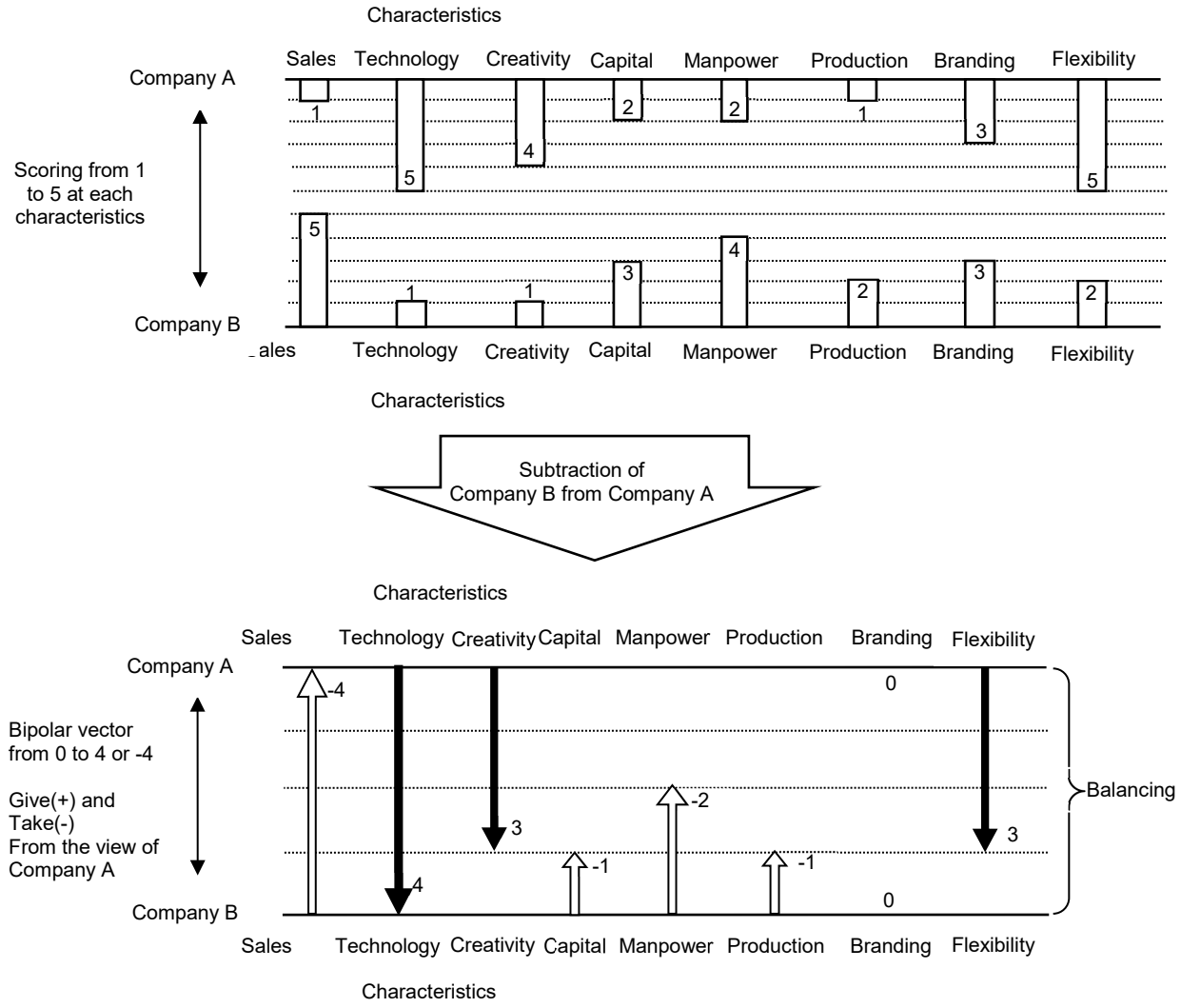
Import of the Concept of Give and Take - Explanation by Flow Intensity and Flow Balance

In the previous sections, the outline of this mutual complementary mathematical model proposed by Tomita and Takefuji (2015, 2016a, 2016b, 2016c). In their papers, the model was simply explained by the spin glass model of magnetic force. Furthermore, in Tomita and Takefuji (2016d) and Tomita (2017), the concept of flow in physics and Give and Take in psychological science are incorporated into the construction of the model as backgrounds of the theoretical concept. That is to say, the two terms of flow intensity and flow balance were used to strengthen the framework of the model. In this way, flow intensity was originally used in physics involving electricity and magnets. Also, flow balance was originally used for interpersonal relationships of give and take. In other words, reward and cost between two people. Tomita and Takefuji (2016d) and Tomita (2017) imported these two concepts from other science fields.

The provision of strengths from Company A to Company B is the "Give", and received resources to supplement the weaknesses becomes the "Take". This also applies in reverse the same way. If the strengths offered (Give) from one or both companies is large and complement (Take) for the weaknesses from the alliance partner is large, the mutually complementary relationship will become stronger. If we were to explain this with the concept of flow intensity, we would say that the flow intensity is strong when mutually complementary relationships are strong. Strictly speaking, when the exchange between Give and Take is large. When the mutually complementing strength is weak, we state that the flow intensity is weak.

In this mutually complement model, the stronger the flow intensity, the more likely the alliance is to be successful. However, based on the idea of Give & Take, if the relationship consists only of Gives from one company to another, the relationship will result in burnout. In other words, using another concept, it is necessary to consider flow balance, and it is important to consider the balance of the Gives and Takes between the two companies. In the mutually complement model, when there are bipolar vectors of plus and minus, that is, when the Gives and Takes are bidirectional, the flow balance is maintained and the alliance is more likely to be successful. In this way, we can explain that in the mutually complementary model of an alliance using flow intensity and flow balance, in corporate alliances if the flow intensities of mutually complementary strengths and weaknesses are strong and the flow balance is maintained, and the alliance is more likely to be successful. If we explain this using the concept of flow intensity and flow balance the maximum mutual complementary strength relationship state is that in which the state of maximum flow intensity and flow balance is maintained evenly.

Figure 2: Flow Intensity and Flow Balance between Companies a and b



This figure illustrates the complimentary relationship between Companies A and B by flow intensity and flow balance as new concepts.

As explained in Figure 2, when both plus and minus bipolar vectors are present, the provided strengths (Give) and compensated weaknesses (Take) exist, there is flow intensity and the flow balance is maintained, the alliance can be successful.

Unsuccessful Pattern 1: No Balancing (One-Sided Relationship)

Company A is scored in every characteristic, which are all larger than those of Company B. In this case, Company A is only providing resources to Company B unilaterally with no balancing. In other words, there are only plus' bipolar vectors from Company A to B, making it one-sided. Since there is no appeal for Company B to Company A, in this case the corporate alliance cannot be successful. Conversely, in the case where the scores for Company B are all larger than those of company A, Company B is only providing strengths to Company A unilaterally. With only minus' bipolar vectors, the relationship is one-sided, and because there is no appeal for Company A to Company B, in this case the corporate alliance cannot be successful.

Unsuccessful Pattern 2: No Intensity (Identical Strengths and Weaknesses)

In the case the scores for Companies A and B are identical, there are no complementary benefits for either company, so the corporate alliance cannot be successful. When the strengths and weaknesses of Companies A and B are the same, the flow intensity becomes zero. In this model, we consider a corporate alliance not to be successful when there are only strengths being provided unilaterally in a corporate alliance (plus' or minus' bipolar vectors only), there is no balancing of Give and Take, or the strengths and weaknesses of two companies are identical (flow intensity is zero) and therefore there is no mutually complementary relationship possible. As shown previously in Figure 1, the corporate alliance is only successful when there is a bilateral relationship of both plus' and minus' bipolar vectors, and there is a balance of Give and Take of strengths and weaknesses.

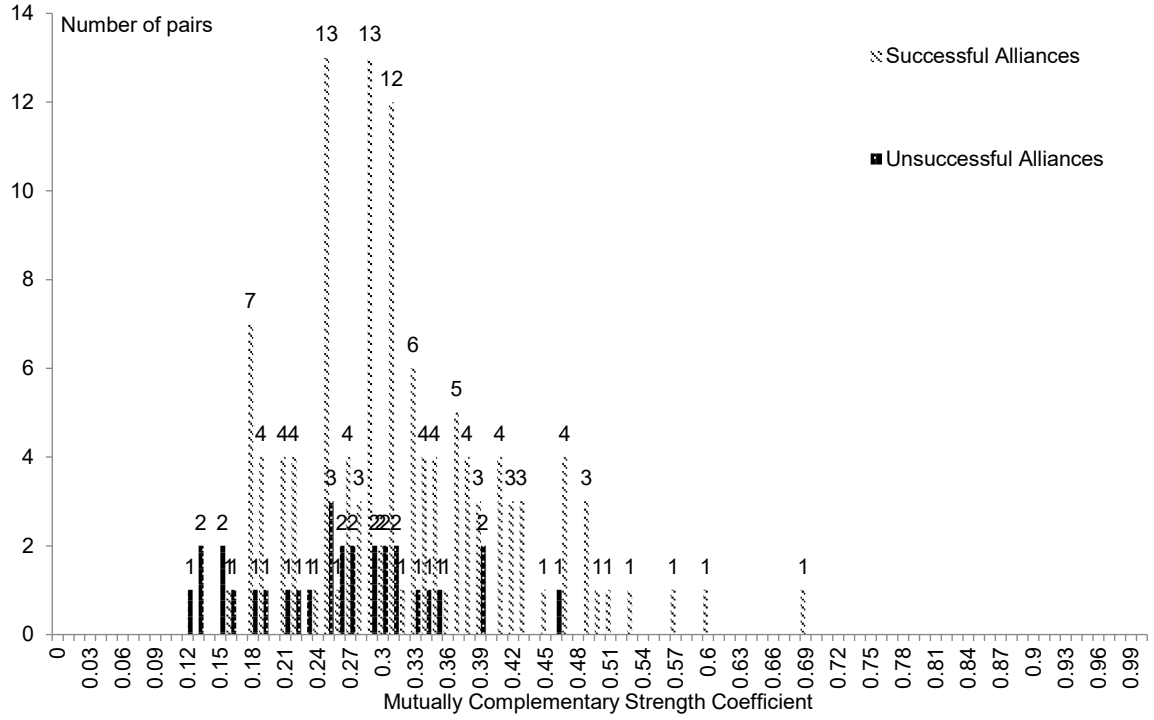
The Status of the Maximum Complementary Relationship: When the Flow is Balanced at the Maximum Flow Intensity

Next, as mentioned in the previous section, we can say the strongest relationship between two companies in a corporate alliance, in which both companies complement each other's strengths and weaknesses at the maximum value, that is to say, the maximum flow intensity. If we explain the maximum mutually complementary strength in this relationship using the concepts of flow intensity and flow balance, this is the state in which the maximum flow intensity state is maintained and the flow balance remains balanced. Although the maximum magnitude of the plus and minus vectors are simply illustrated as 4 consecutive values in sequential order on both the left and right sides, in reality the maximum magnitude of the plus and minus vectors will exist at random across 8 characteristics divided into two groups of four. The state of a maximum mutually complementary relationship occurs when, by taking half of the number of characteristics from both companies, the result is the largest possible bipolar vector indicating the best possible balancing between two companies. In this case, the number of plus' and minus' bipolar vectors are the same, and when the length of the bipolar vector is at its maximum value, it is considered to be the maximum mutually complementary strength.

Programmatic Implementation and Computation by Making Use of the Data set of 152 Consulted Companies

The authors have implemented this formula using the Python scripting language, and have made use of the empirical data set from 152 consulted companies from May 2008 to March 2015 to calculate the mutually complementary strength coefficient for all corporate alliances in the data set, and the data from both the successful and unsuccessful corporate alliances. As a result, we were able to confirm the validity of this proposed model. The above-mentioned formula was implemented in the Python scripting language in Tomita and Takefuji (2015, 2016a, 2016b, 2016c, 2016d) and Tomita (2017), and the mutually complementary strength coefficients were calculated by using 152 consulted companies as empirical data. The validity of the model was confirmed by comparing the coefficients for 121 pairs of successful alliances and 30 pairs of unsuccessful alliances. The graph plotting of the coefficients can be seen in Figure 3 below. The model was proven to be valid.

Figure 3: The Normalized Mutually Complementary Strength Coefficients for Successful Corporate Alliances and Unsuccessful Corporate Alliances



This Figure shows the distribution of the mutually complementary strength coefficients for 121 pairs of successful corporate alliances and 30 pairs of not-successful corporate alliances.

CONCLUDING COMMENTS

From the new combination of Resource-Based View (RBV), the concept of flow in physics, the concept of Give and Take in psychology, and the method of cyber informatics in computer science, a brand new model has been developed. This innovative outcome in management studies comes from the combination of several theoretical concepts and imports methodology from other science fields, specifically cyber informatics of computer science. This outcome must have meaningfully significant implications for innovation in management research. The method of this research activity was accorded to the way of thinking as stated by Schumpeter, quite "a new combination." This paper asserts that the invention in research activities should not focus solely on one specific field or discipline, but in order to successfully create new inventions like this development of mathematical model, researchers must be more open and flexible to borrow theories and concepts from other science fields and across disciplines as well as to combine them as this is the key to creating new, successful inventions in management studies. For future consideration, more concepts and methodologies from other research fields should be imported to management studies for acquiring new inventions. By taking this stance, even greater developments in management studies can be achieved.

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