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Strategic Alliance Decision-making for the Auto Industry base on an Integrate DEA and GM(1,1) Approach

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Abstract

Strategic alliance promotes enterprise resources sharing and enhances the competitiveness of the marketplace. Therefore, finding a mutually beneficial partner to make a strategic alliance is an important issue for various industries. The aim of this paper is to propose a suitable method based on Grey theory and Data Envelopment Analysis (DEA). A method predicts future business and measure operation efficiency, by the use of critical input and output variables. From this, firms can find out their appropriate candidates. This research was implemented with realistic public data from four consecutive financial years (2009-2012) of twenty Auto Manufactures. The study tries to help target firm find the right alliance partners. The results show the most priori candidates in recent years. The study will be of interest for managers of Auto Manufacture in utilizing alliance strategy.

Keywords: Strategic alliance; Auto industry; Grey; Data Envelopment Analysis.

1. Introduction

The Auto industry is an important part of global economics. It has strong linkages with growth, income, employment and innovation. Haugh et al (2010) stated that the Auto industry's cycle is intertwined with business cycles. Hence, this industry has been severely affected by the economic downturn. Despite automakers trying various solutions, auto production is still below its pre-crisis level in recent years.

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According to OICAs' report (2012), the study investigated the top 50 auto companies in World Ranking. However, this research was conducted on only 20 companies which play major roles and can fully represent the Auto industry. Among them, Nissan Motor Company is ranked sixth by product volume. Established in Japan in 1933, Nissan now manufactures vehicles in 20 countries. It also provides products and services in more than 160 countries. Figure 1 shows ten important markets covered around the world by Nissan. The three biggest are being China, the U.S. and Japan.

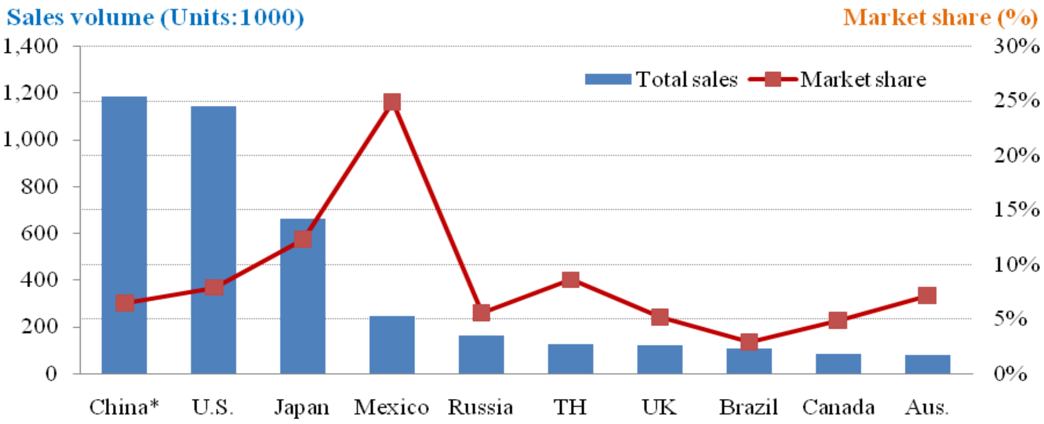

Figure 1. Top 10 Nissan markets, 2012 (*Source: Nissan; modified by researcher)*

However, the company has been faced with a number of challenges, such as product recall (about 1 million and 1,053,479 vehicles globally in 2012 and 2014 respectively, with airbag problem), Reuter (2014). Furthermore, Nissan's annual report in (2013) said they aimed at increasing their global market share from 5.6% to 8% by the end of the fiscal year in 2016. The company is counting on expansion in emerging markets such as Brazil, Russia, India and China—known as the BRIC countries—to drive sales and profit growth.

The questions now arises, how does Nissan maintain their competitiveness in fierce markets, utilize resources, expand scale, produce high quality products with low-cost and protect the environment.

The purpose of this research is to provide an assessment model based on Grey theory and Data Envelopment Analysis (DEA). The model predicts firms' future business and measures operation efficiency by using critical input and output variables. From this, firms can find the right partners when setting global strategies. The results of this case study can be referenced for worldwide Auto manufacture's strategic alliances partner selection.

2. Literature Review

2.1. Strategic alliances

Strategy alliances are a critical success factor for a wide range of companies, such as "British Petroleum, Eli Lilly, General Electric, Corning Glass, Federal Express, IBM, Starbucks, Cisco Systems, Millennium Pharmaceuticals, and Siebel Systems"(James et al., 2003). In this section, the study gives definitions of strategic alliances and provides an overview about strategic alliances.

International strategic alliances (ISAs) are voluntary, long-term, contractual, cross-border relationships between two firms, designed to achieve specific objectives through collaboration

(Brouthers and Bamossy, 2006). The definition emphasizes the importance of common business goals of the involved companies. Cravens et al., (1993) distinguished a strategic alliance as a horizontal collaborative relationship that does not include any kind of equity exchange or creation of a new entity as in joint ventures. Chan et al., (1997) stated: Strategic alliance is a cooperative agreement between different organizations. The purpose of action aims at achieving a competitive advantage and sharing resources in product design, production, marketing, and/or distribution.

These types of alliances can range from simple agreements with no equity ties to more formal arrangements involving equity ownership and shared managerial control over joint activities (Chan et al., 1997). The alliance activities can be supplier-buyer partnerships, outsourcing agreements, technical collaboration, joint research projects, shared new product development, shared manufacturing arrangements, common distribution agreements, cross-selling arrangements etc. The structures or objectives for each enterprise will be dependent on the needs of the firms.

Candace et al., (2011) has researched 89 high technology alliances (including competitor and non-competitor alliances). They point out that the gains to shareholders involved in alliances among competitors are significantly lower than those involved in non-competitor alliances. These results suggest that direct-competitor alliances may be an inefficient means of innovation. Cho et al., (2006) observes the increasing competition of the world telecommunication industry and seeks to answer whether an alliance strategy needs to be regulated by the government. By reviewing global alliance strategies in certain countries, this research develops a direction for telecommunication companies. Kauser and Shaw (2004) investigated the strategic alliance agreements between UK firms and their European, Japanese and US partners. The results indicated that the majority of UK firms improved market share and enhanced their marketing activities.

2.2. Grey system theory and DEA

Forecast time series has been applied quite liberally by researchers. There are various forecasting models such as neural networks, trend extrapolation, fuzzy predictors and grey prediction. Grey system theory was first introduced as an interdisciplinary scientific area by Deng (1982). The Grey theory helps to solve problems of uncertainty, under partially unknown parameters and/or poor or missing information. Grey models need only a limited amount of data to evaluate the action of unknown systems (Deng, 1989).

DEA was introduced by Charnes et al., (1978). The authors proposed a “data oriented” approach for measuring the performances of decision making units (DMU’s).The method converts multiple inputs into multiple outputs. DMU’s can be manufacturing units, universities, schools, bank branches, hospitals, power plants etc.

Recently, there were various DEA and Grey applications in both the private and public sectors. Yuan and Tian (2012) applied the two-stage method of DEA model to analyze the science and technology resources efficiency of industrial enterprises and its influencing factor. Wang et al., (2010) used Grey relation analysis and DEA techniques to measure production and marketing efficiencies of 23 companies in the printed circuit board industry. Wang et al., (2007) applied the data envelopment analysis and the heuristic technique approach to help department stores find proper partners for strategic alliances. Martín and Roman (2001) used DEA to analyze the technical efficiency and performances of Spanish airports as well.

3. Methodologies

3.1. Research development

In this study, the GM (1, 1) and DEA models were used to establish a systematic forecasting and assessment approach. Figure 2 provides an overview of how to integrate Grey and DEA through detailed steps. The works of data collection and inputs-outputs selection are done first in this research. Forecast work is performed in step 3 by using Grey model GM (1, 1).Step 4 employs MAPE to measure the prediction accuracy. The study has to reselect input and output factors once there is a high enough level of error.

In part 3, the super-SBM- I-V model of DEA-Solver software is used to calculate during step 5. Step 6 employs Pearson Correlation Coefficient Test to check correlation values between in inputs and outputs and whether they are positive or not. If the variables receive negative coefficients, they will be removed. The research backs to rebuild new variable until they can meet our requirement.

The aim of step 7 is to find out the target firm’s position in comparison with the other 19 Autos competitors via ranking the efficiency of each decision making unit. Step 8 is implemented to establish new virtual alliances via combining the target DMU with the other DMUs respectively. After consolidation, the supper-SBM-I-V model is used to evaluate and rank new companies in comparison with original ones. Based on the results of this step, suggestions are provided, but by no means is a full list feasible until the full analysis of step 9. In this step, the researcher plays the role of candidate companies which are selected for target firms’ alliance to obtain possible ways of consociation.

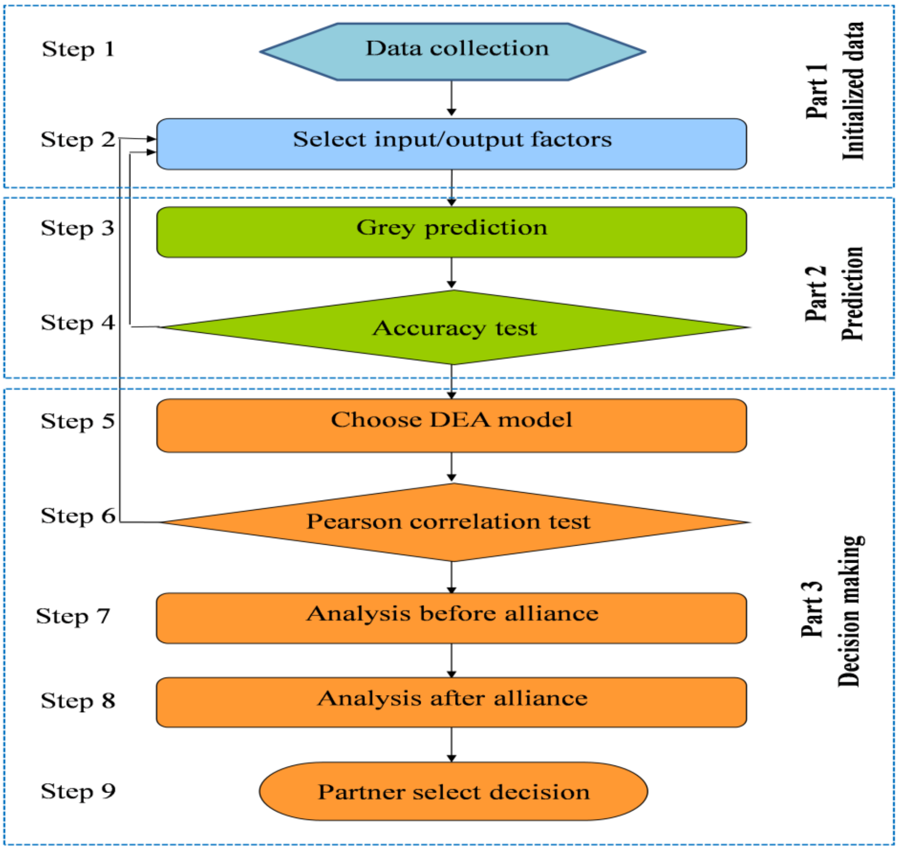

Figure 2. Research development

3.2. Collecting DMUs and establishing inputs/outputs

This research looked at the top 20 Auto makers in World Ranking of Manufacturers – OICA. They have been steady in the market and can provide the complete data for four consecutive financial years (2009-2012) Bloomberg Business week news. Moreover, these collected companies can represent the whole auto industry in the global market (Table1).

Table 1. List of Auto Manufacture Companies

Code DMUs	Companies	Nation	Founded year
TOYOTA	Toyota Motor Corporation	Japan	1937
GM	General Motors Company	U.S	1908
VOLKSWAGEN	Volkswagen Group AG	Germany	1937
HUYNDAI	Hyundai Motor Company	Korea	1967
FORD	Ford Motor Co	U.S	1903
NISSAN	Nissan Motor Co. Ltd	Japan	1933
FIAT	Fiat Autos S.p.A	Italy	1899
HONDA	Honda Motor Co., Ltd	Japan	1948
SUZIKI	Suzuki Motor Corporation	Japan	1909
RENAULT	Renault S.A	France	1899
DAIMLER	Daimler AG	Germany	1926
BMW	Bayerische Motoren Werke AG(BMW)	Germany	1916
MAZDA	Mazda Motor Corporation	Japan	1920
DONGFENG	DongFeng Motor Corporation	China	1969
MITSUBISHI	Mitsubishi Motors Corporation	Japan	1970
CHANGAN	Chang An Auto (Group) Co Ltd	China	1862
TATA	Tata Motors Ltd (TTMT)	India	1945
GEELY	Geely Auto Holdings Ltd	China	1986
ISUZU	Isuzu Motors Ltd	Japan	1916
DAIHATSU	Daihatsu Motor Co. Ltd	Japan	1907

Source: World Ranking of Manufacturers – OICA, *2012*

In order to adequately measure the efficiency of a DEA model, the input and output selections should be carefully considered. Fixed assets, cost of goods sold, operating expenses and long-term investment are considered the essential inputs based on several factors. Literature reviews of DEA, the operations of several Auto companies, the standards of international accounting and the correlation test between input-output factors. Revenues, total equity and net incomes are considered the essential output factors because these indicators provide a signal to measure the benefits and longevity of firm for all owners and investors.

3.3. Grey Forecasting Model

The GM (1, 1) model in this paper is built based on two steps: reducing the randomization of the original data by accumulated generation operation (AGO) and finding the predicted values of raw data via inverse accumulated generation (IAGO). The requirement of data series must be more than four and in consecutive order (Deng, 1989).

Build the initial series $X^{(0)}$by

$$X^{(0)} = \left(X^{(0)}(1), X^{(0)}(2), \dots, X^{(0)}(n)\right), n \geq 4 \quad (1)$$

Where $X^{(0)}$ is a non-negative sequence and *n* is the observed number.

Create$X^{(1)}$ series by executing the AGO: $X^{(1)} = \left(X^{(1)}(1),\ X^{(1)}(2), \dots, X^{(1)}(n)\right),\ \ n \geq 4$ (2)

Where $X^{(1)}(1) = X^{(0)}(1)$ and $\mathrm{X}^{(1)}(k) = \sum_{i=1}^{k} X_{(i)}^{(0)}, \quad k = 1, 2, 3, \dots, n.$ (3)

Finding the mean value series $Z^{(1)}$ of adjacent data$X^{(1)}$:

$$Z^{(1)} = \left(Z^{(1)}(1),\ Z^{(1)}(2), \dots, Z^{(1)}(n)\right) \quad (4)$$

Where $Z^{(1)}(k)$ is computed as follow:

$$Z^{(1)}(k) = 1/2 \times \left(X^{(1)}(k) + X^{(1)}(k-1)\right), \quad k = 2,3,\ldots,n. \tag{5}$$

To build GM (1, 1) model by establishing first order differential equation for $X^{(1)}(k)$.

$$\frac{dX^{(1)}(k)}{dk} + aX^{(1)}k = b \tag{6}$$

Where a and b are developing coefficient and grey input respectively.

The least square method solves Eq.(6) to find parameters a and b:

$$\begin{bmatrix} a \\ b \end{bmatrix}^T = (B^TB)^{-1}B^T\bar{Y}_N \tag{7}$$

$$B = \begin{bmatrix} -Z^{(1)}(2) & 1 \\ \ldots\ldots\ldots & \ldots \\ -Z^{(1)}(n) & 1 \end{bmatrix} \tag{8}$$

And $$Y_N = \begin{bmatrix} X^{(0)}(2) \\ \ldots\ldots\ldots \\ X^{(0)}(n) \end{bmatrix} \tag{9}$$

(B is data matrix; Y is data series, and $[a,b]^T$ is parameter series).

Based on E.q (6), solving $X^{(1)}$(k) at time k by equation:

$$\hat{X}^{(1)}(k+1) = \left[X^{(0)}(1) - \frac{b}{a}\right]e^{-ak} + \frac{b}{a} \quad (k = 1,2,3,\ldots) \tag{10}$$

We obtained $\hat{X}^{(1)}$from Eq. (10). Let $\hat{X}^{(0)}$be the GM (1,1) fitted and predicted series

$$\hat{X}^{(0)} = \left(\hat{X}^{(0)}(1), \hat{X}^{(0)}(2), \ldots, \hat{X}^{(0)}(n), \ldots\right), \; where\; \hat{X}^{(0)}(1) = X^{(0)}(1) \tag{11}$$

Finally, the inverse accumulated generating operation (IAGO) is used to establish the following grey model to find the predicted value of the primitive data at time (k+ 1):

$$X^{(0)}(k+1) = \left[X^{(0)}(1) - \frac{b}{a}\right]e^{-ak}(1-e^{a}) \quad (k = 1,2,3,\ldots) \tag{12}$$

3.4. Non-radial Super Efficiency Model (Super-SBM)

The model of super SBM was developed on a non-radial model called "Slacks-based measure of efficiency" (SBM) introduced by Tone (2001). SBM deals with n DMUs with input matrices $X = (x_{ij}) \in R^{m\times n}$ and output matrices$Y = (Y_{ij}) \in R^{s\times n}$. λ is a non-negative vector in R^n. The slack vectors $S^- \in R^m$ and $S^+ \in R^s$ are the input excess and output shortfalls respectively. The efficiency of DMU (x_0, y_0) in SBM equation was formulated by author as follows:

$$\min \quad \rho = \frac{1-\frac{1}{m}\sum_{i=1}^{m} S_i^-/x_{i0}}{1+\frac{1}{s}\sum_{i=1}^{s} S_i^+/y_{i0}} \tag{13}$$

$$\text{s.t} \quad x_0 = X\lambda + S^-, y_0 = Y\lambda - S^+, \; \lambda \geq 0, S^- \geq 0, S^+ \geq 0. \tag{14}$$

Suppose an optimum solution for SBM be$(p^*, \lambda^*, S^{-*}, S^{+*})$. A DMU (x_0, y_0) is SBM-efficient if $p^* = 1$. That means $S^{+*} = 0$ and $S^{-*} = 0$ (no output shortfalls and no input excesses). According to this assumption, Tone (2002) has presented a super-efficiency model for ranking DMUs as following:

$$\min \quad \delta = \frac{\frac{1}{m}\sum_{i=1}^{m} \bar{x}_i/x_{i0}}{\frac{1}{s}\sum_{r=1}^{s} \bar{y}_r/y_{r0}} \tag{15}$$

s.t $\bar{x} \geq \sum_{j=1,\neq 0}^{n} \lambda_j x_j,\ \bar{y} \leq \sum_{j=1,\neq 0}^{n} \lambda_j x_j,\ \bar{x} \geq\ x_0, and\ \bar{y} \leq\ y_0, \bar{y}\ \geq 0,\ \lambda \geq 0$ (16)

If denominator equal to 1, we will get the input-oriented of super SBM model. The equation returns a value greater or equal to one (≥1).

4. Empirical result analysis

4.1. Prediction results and Accuracy test

GM (1, 1) model was used to predict the input and output variables in the next two years 2014and 2015. The results were shown in the tables 2 and 3.

Table 2. Predicted inputs value of all DMUs in 2014& 2015 (calculated by GM)

DMUs	Inputs (million U.S dollars)							
	(I) Fixed assets		(I) Cost of goods sold		(I) Operating expenses		(I) Long-term investments	
	2014	2015	2014	2015	2014	2015	2014	2015
TOYOTA	70,413.76	73,483.48	191,650.86	204,006.60	19,977.15	20,527.60	93,747.48	108,084.44
GM	30,627.70	34,180.64	156,272.06	167,032.77	13,016.29	13,398.38	5,405.02	4,858.26
VOLKSWAGEN	113,331.34	140,960.54	291,902.59	358,669.67	44,762.03	56,169.45	16,128.22	14,981.20
HUYNDAI	36,258.06	42,119.12	77,479.65	87,073.07	12,014.97	12,820.75	20,686.37	24,977.25
FORD	27,815.41	28,942.67	122,750.53	127,296.04	12,328.22	12,486.67	3,869.90	4,303.37
NISSAN	49,646.84	54,587.47	86,733.22	91,750.42	10,443.65	10,457.33	6,500.89	6,970.56
FIAT	49,500.27	66,896.38	211,632.54	314,516.76	23,721.66	33,868.48	3,496.89	3,827.76
HONDA	28,104.71	31,457.87	77,477.92	83,034.33	20,598.48	21,524.24	6,690.12	6,898.76
SUZIKI	6,641.82	7,197.72	17,639.22	17,334.28	4,814.64	4,814.34	3,003.91	3,382.35
RENAULT	15,654.93	15,675.52	52,518.61	55,272.27	8,936.91	8,943.62	24,508.49	25,435.82
DAIMLER	75,368.02	84,144.95	142,489.36	155,030.57	27,340.84	28,849.28	10,411.14	10,894.33
BMW	14,602.18	14,608.35	84,506.77	97,209.21	10,096.02	10,961.02	6,184.21	7,414.83
MAZDA	7,501.30	7,492.53	14,919.84	14,344.18	3,827.89	3,754.38	1,625.66	1,841.14
DONGFENG	5,910.84	6,982.03	17,601.59	17,957.60	2,741.05	2,858.04	435.97	504.94
MITSUBISHI	3,719.87	3,736.29	13,508.74	13,223.65	2,857.13	2,992.71	384.85	274.56
CHANGAN	5,087.33	7,472.60	3,243.71	3,004.46	1,060.54	1,113.70	1,715.08	1,947.94
TATA	8,711.31	10,548.70	32,666.32	39,676.74	10,619.74	13,961.21	277.13	295.59
GEELY	1,495.35	1,679.87	4,025.09	4,472.01	568.48	627.13	125.46	267.39
ISUZU	4,910.16	4,993.69	15,218.75	16,420.50	1,292.45	1,356.71	2,022.37	2,461.32
DAIHATSU	4,538.48	4,700.56	14,971.97	15,878.81	2,846.08	2,997.43	7,607.51	8,755.01

Table 3. Predicted outputs value of all DMUs in 2014 & 2015 (calculated by GM)

DMUs	Outputs (million U.S dollars)					
	(O) Revenues		(O) Total equity		(O) Net income	
	2014	2015	2014	2015	2014	2015
TOYOTA	241,504.55	261,557.19	141,719.50	153,789.82	24,362.25	45,908.52
GM	172,645.77	182,629.77	37,482.81	37,405.20	7,204.33	7,211.34
VOLKSWAGEN	396,104.07	486,502.94	185,122.41	239,443.35	25,863.08	31,913.66
HUYNDAI	100,404.62	112,444.61	65,297.01	78,620.97	12,241.57	14,952.26
FORD	141,225.34	144,029.75	71,908.71	135,459.71	9,942.31	9,668.22
NISSAN	101,922.80	106,703.91	48,224.54	54,014.53	3,553.15	3,677.40
FIAT	249,848.23	371,774.80	18,715.51	19,258.49	782.86	722.16
HONDA	100,975.49	106,762.56	55,581.37	59,384.75	1,475.01	1,113.68
SUZIKI	24,153.86	24,012.10	14,396.89	15,655.26	1,373.92	1,867.88
RENAULT	60,483.01	62,169.42	36,375.50	37,742.23	1,063.94	741.97
DAIMLER	181,919.67	196,616.42	74,103.59	81,167.79	11,252.45	12,992.22
BMW	132,749.60	149,508.66	52,477.50	59,118.70	10,759.12	13,147.74
MAZDA	19,255.56	18,714.16	5,870.65	6,405.79	- 80.73	- 46.62
DONGFENG	21,203.11	21,338.69	13,223.36	15,581.20	1,274.57	1,163.30
MITSUBISHI	17,250.60	17,187.01	4,752.21	5,721.35	848.70	1,320.21
CHANGAN	3,962.79	3,687.62	3,628.82	4,273.57	117.18	92.45
TATA	46,913.97	57,573.24	11,392.44	15,255.90	1,910.46	1,959.33
GEELY	4,937.47	5,487.11	3,158.36	3,843.04	500.50	617.16
ISUZU	18,257.36	19,836.99	9,470.57	12,022.96	1,630.50	2,116.33
DAIHATSU	19,460.05	20,717.02	25,157.75	32,072.49	1,223.93	1,522.91

The predicting future results are based on present uncompleted information. Hence, the Mean Absolute Percent Error (MAPE) is used to measure the accuracy values in statistics. The smaller MAPE values demonstrate the forecasting result is more reasonable. Stevenson and Sum define MAPE in their book as follow:

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\frac{|\text{Actual}_t - \text{Forecast}_t|}{\text{Actual}_t} \times 100;$$ (n is number of periods).

The percentages of MAPE express the reliable forecasting as follow levels:

50%<MAPE "Poor", 20% < MAPE < 50% "Qualified",

10% < MAPE <20% "Good", 10%>MAPE "Excellent".

The results of MAPE are shown as in table 4.

Table 4. Average MAPE of DMUs

DMUs	Average MAPE	DMUs	Average MAPE
TOYOTA	5.8480%	DAIMLER	0.7924%
GM	3.5243%	BMW	1.3078%
VOLKSWAGEN	1.9018%	MAZDA	10.8717%
HUYNDAI	1.7133%	DONGFENG	1.6580%
FORD	45.3331%	MITSUBISHI	3.0785%
NISSAN	1.5143%	CHANGAN	6.5681%
FIAT	11.4944%	TATA	3.8313%
HONDA	6.6490%	GEELY	3.4808%
SUZIKI	3.9993%	ISUZU	2.6710%
RENAULT	2.2275%	DAIHATSU	0.6805%
Average MAPE of 20 DMUs		*5.9573%*	

Most of MAPE values are excellent (smaller than 10%).Average of all MAPE is 5.9573% affirm that GM (1,1) model provides a high accurate forecast.

4.2. Pearson correlation test

Correlation was carefully checked to ensure the relationship between input and output variables is isotonic (an increase in any input should not result in a decrease in any output) Golany and Roll (1989).The factors are that isotonic relations (positive correlation coefficient) will go with the DEA model; if not it will be reexamined Lo et al., (2001).

The result of correlation coefficients in table 5 shows strong positive associations and matches with DEA model's precondition. Therefore, these input and output variables are appropriate.

Table 5. Correlation of input and output data

	Fixed assets	Cost of goods sold	Operating expenses	Long-term investments	Revenues	Total equity	Net income
Fixed assets	1	0.916378	0.921629	0.632545	0.925523	0.913111	0.85602
Cost of goods sold	0.916377	1	0.898532	0.594043	0.992487	0.861108	0.857803
Operating expenses	0.921629	0.898532	1	0.481858	0.919848	0.860337	0.84896
Long-term investments	0.632545	0.594043	0.481858	1	0.580518	0.796618	0.50826
Revenues	0.925523	0.992487	0.919848	0.580518	1	0.886316	0.897967
Total equity	0.913110	0.861108	0.860337	0.796617	0.886316	1	0.874886
Net income	0.856015	0.857803	0.84896	0.508260	0.897967	0.874886	1

4.3. Alliance analysis

This paper uses Super-SBM-I-V to measures 20 DMUs' efficiency and sort ranking before alliances, with the realistic data (2009-2012). Empirical results indicated that GEELY is the 1st ranking efficiency firm (score = 5.8965750), followed by BMW and DONGFENG. Nevertheless, the target NISSAN stays at the last group with the 18thposition of total 20 companies. It only scores 0.6492883 (see Table 6). These points reflect the company has long-term adverse business efficiency. Hence, the firm should seek advantages from cooperative partners via building a creative alliance strategy.

Table 6. Efficiency ranking before alliances

Rank	DMU	Score
1	GEELY	5.8965750
2	BMW	1.5655136
3	DONGFENG	1.3982037
4	TATA	1.3777954
5	DAIHATSU	1.3447020
6	FORD	1.2097953
7	GM	1.1359231
8	HUYNDAI	1.0876949
9	ISUZU	1.0484095
10	HONDA	1.0307413
11	FIAT	1.0133168
12	TOYOTA	1
12	VOLKSWAGEN	1
14	DAIMLER	0.7448770
15	SUZIKI	0.7176400
16	MITSUBISHI	0.7105391
17	RENAULT	0.7104498
18	NISSAN	0.6492883
19	MAZDA	0.5816934
20	CHANGAN	0.5283717

To implement empirical results, 39 virtual alliances were formed by combining NISSAN with the rest of the DMUs. Afterwards, the software of DEA-Solver Pro 5.0 -- Super-SBM-I-V model built by Saitech Company was applied to compute efficiency for all new DMUs. The ranking results and scores are shown in Table 7.

Table 7 indicates the changing from original DMUs to virtual alliance in difference efficient. Researchers can thus compare the efficiency by separating them into three different groups (see Table 8). The group has positive results in difference proving these alliances are better than original DMUs. The higher difference value is the more efficient of alliance. In contrast, the negative value of the second group means the alliance is worse.

Table 7. Performance ranking of virtual alliance

Rank	DMU	Score	Rank	DMU	Score
1	GEELY	5.8965750	21	NISSAN+HUYNDAI	0.9011136
2	BMW	1.5655136	22	NISSAN+DAIMLER	0.8376827
3	DONGFENG	1.3982037	23	NISSAN+DAIHATSU	0.7731485
4	TATA	1.3777954	24	NISSAN+DONGFENG	0.7545630
5	DAIHATSU	1.3447020	25	NISSAN+RENAULT	0.7462483
6	FORD	1.1714878	26	DAIMLER	0.7229771
7	VOLKSWAGEN	1.1161306	27	SUZIKI	0.7176400
8	TOYOTA	1.1140650	28	NISSAN+SUZIKI	0.7113479
9	GM	1.1058616	29	MITSUBISHI	0.7105391
10	HUYNDAI	1.0876949	30	RENAULT	0.7104498
11	NISSAN+FORD	1.0655124	31	NISSAN+TATA	0.7013426
12	ISUZU	1.0484095	32	NISSAN+ISUZU	0.6720799
13	NISSAN+BMW	1.0443239	33	NISSAN+GEELY	0.6649845
14	NISSAN+GM	1.0400331	34	NISSAN	0.6492883
15	HONDA	1.0282731	35	NISSAN+MITSUBISHI	0.6279972
16	FIAT	1.0133168	36	NISSAN+CHANGAN	0.6265420
17	NISSAN+HONDA	1.0117510	37	NISSAN+MAZDA	0.6219810
18	NISSAN+FIAT	1.0002026	38	MAZDA	0.5816934
19	NISSAN+VOLKSWAGEN	1	39	CHANGAN	0.5283717
19	NISSAN+TOYOTA	1			

In Table 8, in group 1 and 2, the target DMUs' ranking raised after alliance with the other 16 companies (TOYOTA, GM, VOLKSWAGEN, HUYNDAI, FORD, FIAT, HONDA, SUZIKI, RENAULT, DAIMLER, BMW, DONGFENG, TATA, GEELY, ISUZU and DAIHATSU). This demonstrates that alliance brings advantages for target firm. The alliance of NISSAN+FORD, NISSAN+BMW, NISSAN+GM, NISSAN+HONDA and NISSAN+FIAT gets the highest efficiency (score >1).Those 5 candidates should be the first to be considered with an alliance partner. Particularly, FORD is one of the most potential candidates because of its largest difference value (23).The third group having three firms including (MITSUBISHI, CHANGAN, and MAZDA) which lead NISSAN gets worst after strategic alliances than its standing alone (ranking reduced).Hence, those firms would not be option of the Target Company because they do not help the company in its vision.

Table 8. The feasibility between, a good & bad alliance partnership

Number order	Virtual alliance	Target NISSAN ranking (1)	Virtual alliance ranking (2)	Difference (1) - (2)
1st group		Feasible alliance		
1	NISSAN+DAIMLER	34	22	12
2	NISSAN+RENAULT	34	25	9
2 nd group		Good alliance		
1	NISSAN+FORD	34	11	23
2	NISSAN+BMW	34	13	21
3	NISSAN+GM	34	14	20
4	NISSAN+HONDA	34	17	17
5	NISSAN+FIAT	34	18	16
6	NISSAN+VOLKSWAGEN	34	19	15
7	NISSAN+TOYOTA	34	19	15
8	NISSAN+HUYNDAI	34	21	13
9	NISSAN+DAIHATSU	34	23	11
10	NISSAN+DONGFENG	34	24	10
11	NISSAN+SUZIKI	34	28	6
12	NISSAN+TATA	34	31	3
13	NISSAN+ISUZU	34	32	2
14	NISSAN+GEELY	34	33	1
3nd group		Bad Alliance		
1	NISSAN+MITSUBISHI	34	35	-1
2	NISSAN+CHANGAN	34	36	-2
3	NISSAN+MAZDA	34	37	-3

4.4.Partner selection

In the previous section, the good alliance partnerships were found based on the position of the target NISSAN. Nevertheless, we need to further analyze the feasibility of an alliance partnership. We should then also contrast new virtual incorporation with its own original position.

Clearly such as the statement of table 8, there are fourteen good partners. However, they would not will to cooperate with the target firm. Because, they were reduced ranking after alliance in comparison with original ones. In other word, the performances of TOYOTA, GM, VOLKSWAGEN, HUYNDAI, FORD, FIAT, HONDA, SUZIKI, BMW, DONGFENG, TATA, GEELY, ISUZU and DAIHATSU are already good; if no special circumstances, they now will not need to make the alliance partnership with the NISSAN.

Hence, the efficient of each DMU before and after alliance were reviewed again in table 6, table 7 and table 8.Those tables clearly highlight the combination between RENAULT and DAIMLER with the target NISSAN. Before alliance, RENAULT and DAIMLER do not reach the DEA frontier; nevertheless, their rankings are improved after cooperating with NISSAN. It demonstrates that the alliance can bring a good scene not only for the NISSAN but also for the RENAULT and DAIMLER. In other words, via implementing alliance, both of NISSAN-RENAULT and NISSAN-DAIMLER might have the opportunities to manage their resources more effectively. Hence, RENAULT and DAIMLER would have strong desire to form alliance.

Comparisons with NISSAN-RENAULT have suggested that the strategic alliances from 1999 to now are developing a multiparty alliance between NISSAN-RENAULT-DAIMLER. This one again proved the recommends RENAULT and DAIMLER to cooperate with the target company NISSAN are correct and has practical feasibility.

In short, the results and findings of the case study are also new recommendations of strategic alliance partner selection. The readers can clearly recognize the noticeable candidates for alliance strategy are FORD (the best efficiency improvement for the target company) and the RENAULT, DAIMLER (the efficiency improvement for both parties).

5. Conclusions

Today, auto makers are facing numerous challenges including; how to obtain new technology and resources, how to reduce risk and share costs of research and development, and how to achieve competitive advantage. This is without mentioning new growth strategies and how to enter new markets. This research approached these problems by using Grey Theory and DEA to construct a model for strategic alliance. The model focuses on the relationship between strategic alliance and firms' performances in the Auto industry.

Based on the data of auto makers from 2009-2012, this research uses the GM (1, 1) model to predict the future value change of the specific input and output factors. The forecast value has been tested accurately by average MAPE and received a consistent percentage of 5.9573%.

In this model, Nissan was used to test the strategic alliance benefits with several other companies. DEA-Super SBM model was used to measure the operational efficiency of real DMU's and virtual DMU's. The results showed that sixteen partnerships were acceptable candidates for NISSAN to form strategic alliances with. Among the top companies were FORD, BMW, GM, HONDA and FIAT. However, these companies were not realistically feasible for Nissan to pursue. In actuality, research found only two companies, RENAULT and DAIMLER**,** to be feasible alliance partners for NISSAN.

In this model, some DMU efficiency was improved, whereas, some of them decreased. This indicates that strategic alliance does not always generate benefits. Thus before a company decides to use strategic alliance, it is necessary to deeply consider and assess the many aspects involved in creating a strong partnership.

In conclusion, the integrating of GM (1, 1) and Super - SBM model provides an accurate approach to forecast and evaluate Auto firms. This model provides a meaningful example for managers when choosing a strategic alliance strategy, with particular emphasis on the Auto industry.

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