Measuring company performance from an environmental perspective: a composite indicator for truck manufacturers

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Abstract

This paper aims to construct a composite indicator for truck companies to quantify their performance with an environmental perspective, by mathematical models rather than heavily by subjective scoring. Tobin's Q is used as an indication of company performance. The bivariate correlation analysis, a modified linear technique based on min-max normalization and a geometric mean with unequal weights are used to construct that composite indicator. The method is transparent, and the composite indicator derived can serve as a statistical tool for benchmarking. A case study is conducted in three truck companies from the fiscal year 2008 to 2016.

Keywords: Performance measure, Composite indicator

Introduction

Performance measurement is essential for decision makers to monitor performance and to solve management problems. Currently, companies usually refer to several integrated models (the 4th generation of balanced scorecard, etc.) or to several organizations (Standard & Poor's, Moody's Investors Service and Fitch Ratings, etc.). In spite of their relatively standard ways of assessing company performance (Bhatia 2002), they heavily rely on subjective judgements by experts, and have been criticized for their drastically lowering rankings during economic disruptions. As a main means of freight transport, trucking is influential with respect to the entire economy and environment. Since the

1980s, there has been increasing pressure on truck manufacturers to integrate considerable environmental concerns into daily operations.

In order to develop a statistical tool for truck manufacturers to enhance their decision-making capability for improving company performance, a comparative and quantitative scoring indicator is essential. Around this topic, this research reviewed eight related literature which is at the company level and is within manufacturing sector. In terms of the techniques applied, this research summarized their pros and cons in table 1. This research has no focus on post analysis application. Based on the marked status of the eight references in table 2, this paper finds that current efforts in the field of performance measurement haven't provided a rigorous indicator, which is by mathematical models rather than heavily by subjective scoring, for quantifying truck manufacturers' performance with structured environmental indicators. Thus the research question was proposed as: how to construct that missing composite indicator?

Table 1 - Pros and cons with respect to the methodologies

Application	***Pros***	***Cons***
Indicators' selection	P_1:A detailed list of indicators for specific sectors	C_1: Without particular emphasis on environmental concerns
		C_2: With general indicators not for specific sectors
Indicators' weights	P_2: Objective techniques	C_3: With *AHP/ PCA/* Experts' scoring as the sole tool
		C_4: With the inherent interdependencies of the different sectors not tackled
Normalization	P_3: Normalization with realistic categories	C_5: With unclear techniques
Aggregation	P_4: With aggregating formulas	C_6: Without aggregating procedures
post analysis	P_5: Computational demonstration	C_7: Impractical for computational demonstration due to its complex scenarios designed C_8: Without sensitivity or uncertainty analysis phase

Table 2 - Pros and cons in the literature

Refs.	P_1	P_2	P_3	P_4	P_5	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
(Kao and Hung 2007)	●					●	●		●	●			●
(Elferink et al. 2010)	●		●	●	●	●							●
(Chahid et al. 2014)	●			●	●	●		●	●	●			●
(Gopal and Thakkar 2015)	●		●		●		●		●		●		●
(Salvado et al. 2015)	●		●	●	●		●	●	●	●		●	●
(Grandhi and Wibowo 2016)					●		●		●		●	●	●
(Azevedo and Barros 2017)			●	●	●			●	●				●
(Kocmanova et al. 2017)	●			●	●		●	●		●		●	●

Methodology

To answer the research question, firstly this research listed six requirements for constructing the composite indicator as follows:

1) including non-financial indicators and intangible indicators (Neely et al. 2003);
2) including indicators with respect to environmental issues (Hart 1995);
3) with measurability based on released figure rather than subjective judgements;

4) with realistic assumptions and appropriate modelling techniques;
5) be easy to interpret with relatively simple calculation;
6) be specific for truck manufacturing sector.

As is illustrated in figure 1, the rest of this research is organized as follows:

1) in phase I, a conceptual framework of company performance measurement for truck manufacturers is developed. To identify and validate the underlying criteria, this paper conducts a literature review, and refers to released documents from companies themselves, from the Global Reporting Initiative and the Carbon Disclosure Project, and from professional websites (Newsweek website, e.g.). Tobin's Q is used as an indication of company performance;
2) during phase II to phase V, a composite indicator is mathematically constructed with no subjective weighting. Referring to the paper "Method for performance measurement of car companies from a stability-value leverage perspective" by Dr. Beelaerts van Blokland, etc., this research weighs the indicators via a bivariate correlation analysis. A modified linear technique based on min-max normalization and a geometric mean with unequal weights are used to generate a multiplicative function of company performance.

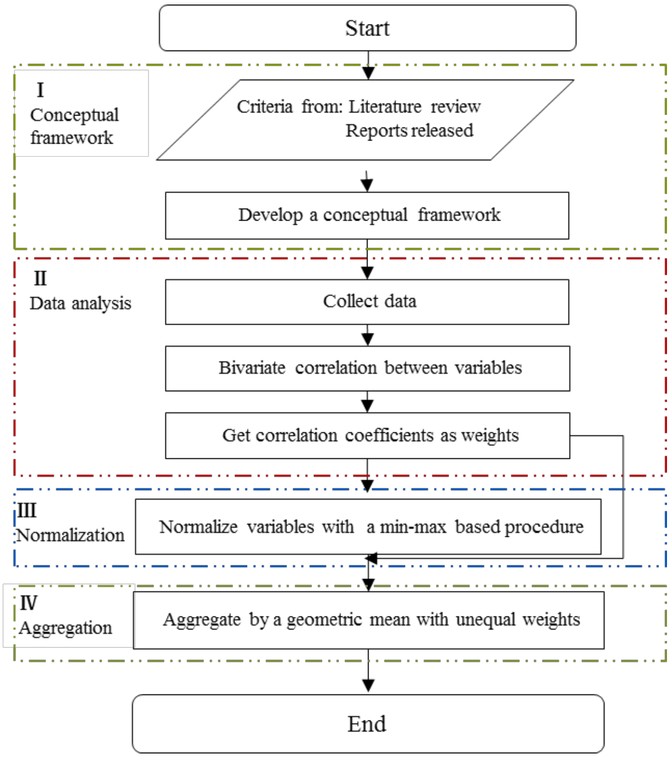

Figure 1 – The flowchart of this research

Tobin's Q

Truck manufacturers need to be more cautious with its market capitalization (Kozmetsky and Yue 1998, Shiu 2006), since it is the "most important measure of size and economic relevance" for a company (Bryan 2007) and stakeholders can tell whether the company has delivered outstanding performance or not. As a stock-based measure of company value (Gompers et al. 2003), Tobin's Q (Tobin 1969) is proved as a much more appealing measure of company performance (Wolfe and Sauaia 2014). Tobin's *Q* isn't subject to managers' influence on profit figures and investment decisions. Besides, Tobin's *Q* is future-oriented, which means it reflects the present value of future cash flows based on current and future information (Devers et al. 2007).

Considering the data availability, referring to (Haslam et al. 2010), this research uses Tobin's *Q* in equation (1) as an indication of company performance. Where "n" represents for the number of a company's outstanding shares, "SP" for the current share price of a single share, t and t-1 for the fiscal year t and t-1 respectively, "*TD*" and "*TA*" for total debt and total assets respectively.

$$Tobin's\ Q\ ratio[\%] = \frac{n[\#] * SP_t[\$] \ + \ [0.5*(TD_t + TD_{t-1})][\$]}{[0.5*(TA_t + TA_{t-1})][\$]} \qquad \text{Equation (1)}$$

Environmental performance

Truck manufacturing is one of the most resource intensive sectors, since the days of cheap or even free resources and pollution charges are long gone, truck manufacturers couldn't disregard the real costs of their performance. Investors and financial institutions are becoming increasingly concerned about company environmental policies (Chang et al. 2015). Environmental performance is an important dimension of organizational performance (Hart 1995). Environmental impacts can be measured in terms of resource consumption, emissions or environmental damage (Hahn et al. 2010). Considering the availability and comparability of data from truck manufacturers, this paper identifies three indicators for environmental performance:

1) CO_2 emission: CO_2 emission reduction is used as a measure for CO_2 emission performance in equation (2), where "CO_2e" represents for the volume of CO_2 emission.

$$CO_2e\ reduction[\%] = (CO_2e_t[Kg] \ - CO_2e_{t-1}[Kg]) / CO_2e_{t-1}[Kg] \qquad \text{Equation (2)}$$

2) Water consumption: water consumption can be regarded as the indicator of the company's impact on water resources (Harik et al. 2015). It can be calculated as the difference between the amount of input water (water use) (Semmens et al. 2014) and water discharge respectively in the reports. This suits for companies who directly release data of water flows and water discharges rather than water consumption, such as Hyundai, Nissan, and Mazda. This paper adopts water consumption on a per-unit (cars produced) basis as a measure in equation (3), where "*N*" is for cars' production volume.

$$\begin{aligned} Water\ consumption\ per\ car\ produced\left[m^3/\#\right] &= Water\ consumption\ \left[m^3\right]/N[\#] \\ &= \left(Water\ input\left[m^3\right] \ - \ Water\ discharge\left[m^3\right]\right)/N[\#] \end{aligned} \qquad \text{Equation (3)}$$

3) Energy consumption: as one of the most important sector in manufacturing industry, truck manufacturing consumed a large volume of energy (Afgan et al. 2000). This paper adopts energy consumption on a per-unit as a measure in equation (4), where "*EC*" represents for the volume of energy consumption.

$$EC\ per\ car\ produced\left[MWh\ /\#\right] = EC[MWh]) / N[\#] \qquad \text{Equation (4)}$$

A conceptual framework with variables

Mainly based on literature review and reports released, this paper develops a new conceptual framework of performance measurement for truck companies in table 3. Noted: the last two dimensions are the authors' own source, "+"denotes indicators with the category "the larger the better", and "-" denotes indicators with the category "the smaller the better".

Table 3 – The conceptual framework of performance measurement

Dimension	Indicator (category)	Variable(s) [Unit]	Reference(s)
Competitive Performance	C_1 (+)Sales	Sales [$], S for sales	(Doyle and Hooley 1992, Simatupang and Sridharan 2005)
	C_2 (+) Market share	Market share [%]	(Govindarajan and Gupta 1985, Kozmetsky and Yue 1998)
Financial performance	C_3 (+) Profitability	Net profit margin [%]	(Doyle 1994, Hsu 2015, Sinkey and Nash 1993)
	C_4 (+) Cash flow margin	Operating cash flow margin ratio [%]	(Chandler and Hanks 1993, Tan 2002, Volpe 2017)
Manufacturing capability	C_5 (+) Productivity	Cars produced per employee [#]=N/E, E for the number of employees	(Brignall et al. 1991, Laitinen 2002)
	C_6 (+) Continuity	Profit per employee [$]=$P/E$	(Beelaerts van Blokland et al. 2010, Bryan 2007)
Innovation capability	C_7 (+) Conception	R&D expenditure per employee [$]	(Keeble and Walker 1994)
Supply chain management	C_8 (+) Configuration	Turnover per employee [$]	(Beelaerts van Blokland et al. 2012, Clark et al. 1995)
Inventory performance	C_9 (+) Inventory turnover	$COGS_t$ / [$0.5*(I_t + I_{t-1})$], $COGS$ for cost of goods sold	(de Jong and Beelaerts van Blokland 2015, Vastag and Whybark 2005)
	C_{110}(-) Inventory efficiency	Inventory to sales ratio= [$0.5*(I_t + I_{t-1})$]/ $NS_{t,}$, GS *for* gross sales	(Capkun et al. 2009, Chen et al. 2007)
Environmental performance	C_{11} (+) CO_2 emission	Equation (2)	—
	C_{12} (-) Water consumption	Equation (3)	(Semmens et al. 2014)
	C_{13} (-) Energy consumption	Equation (4)	—

Data analysis

Data sources

A sample of three leading truck manufacturers are selected in this research, including Paccar Inc. from America, Scania AB from Europe, and Ashok Leyland Ltd. from Asia. No existing dataset is well prepared for all thirteen variables and for Tobin's *Q* ratio in this research, so data had to be drawn from multiple sources. The currency is all adjusted in US dollars so that a comparative analysis can be made. The period is over the nine year period from the fiscal year 2008 to 2016.

Weighing the indicators

Referring to the methods for relative ranking by Dr. Beelaerts van Blokland, etc., in this research, the importance levels (*w*) of the indicators are based upon the degree of the R-value correlation (Field 2013) between the variable "Tobin's *Q*" and the other thirteen variables. IBM SPSS Statistics 23 is used to calculate *P*-values and Pearson's correlation coefficients (the R-value).

Normalizing the variables

The frequently used techniques are standardization (or z-scores) normalization, min-max normalization (also known as re-scaling by minimum method), categorical scales, ratio-scale methods, and several non-linear ones like logarithm function, expectation function and arc-tangent function. This research modifies a linear procedure based on min-max normalization in equation (5), where (*i=1,2,…,m*) represents for the alternative truck companies, *j* (*j=1,2,…,n*) for the individual indicators for company performance x_{ij}^t for the value of indicator j on alternative *i* at fiscal year *t* (*t=0,1,...,T*), $x^{*}{}_{ij}^{t}$ for the normalized value of x_{ij}^t, and $x^*_{ijt} \in (0,1]$. This normalization suits well for this research with the concerns:

1) two different categories for the thirteen indicators for truck companies
2) some measures without commensurability
3) values of some measures less than 1, or even less than 0
4) for the feasibility as a base number in the multiplicative equation (6).

$$x^{*t}_{ij} = \begin{cases} \dfrac{x_{ij}^t}{\max\limits_i x_{ij}^t}, \; for(+) \\ \dfrac{\min\limits_i x_{ij}^t}{x_{ij}^t}, \; for(-) \end{cases}$$ Equation (5)

Aggregating the indicators

In general, there are three kinds of aggregation methods for composite indicators' construction: linear aggregation, geometric aggregation, and the weighted displaced ideal method. Basically, realistic cases violate the preference independence and such a complete compensability is often not desirable. A multiplicative function, by geometric mean with unequal weights aggregation, is expressed in equation (6), where I_i^t is the composite indicator for manufacturers *i* (*i=1,2,…,m*) at fiscal year t, and $I_i^t \in (0,1)$. This research adopts a geometric mean with unequal weights for aggregation, which takes into account three concerns as follows:

1) there is some degree of non-compensability between the thirteen indicators
2) it has better performance on dataset with time series
3) this research won't involve much computational complexity

$$I_i^t = f\left[x_{ij}^{*t}, w_j\right] = \prod_{j=1}^{n} x^{*t}_{ij}{}^{w_j}$$ Equation (6)

Results

The absolute value of the correlations is averaged to calculate the weights w_j in table 4. Normalize the variables, and calculate the values of the composite indicators in the year 2016 for the three companies as in table 5.

Table 4 – R-value over the fiscal year 2008 to 2016

R- value (*C vs. Tobin's Q*)	**Scania**	**Paccar**	**Ashok Leyland**	**Average R-value**
C_1	0.5390	0.3760	0.5020	0.472
C_2	0.3010	0.6240	0.9110	0.612
C_3	0.5320	0.6505	0.7880	0.657

C_4	0.4660	0.5260	0.7250	0.572
C_5	0.6460	0.5210	0.4290	0.532
C_6	0.6230	0.7080	0.8040	0.712
C_7	0.6910	0.8490	0.7200	0.753
C_8	0.8720	0.8690	0.8260	0.856
C_9	-0.4390	0.760	0.6960	0.339
C_{10}	-0.6530	-0.7620	0.5500	-0.655
C_{11}	0.4700	0.6230	0.7910	0.628
C_{12}	-1.5320	-0.1040	-0.7380	-0.791
C_{13}	-0.8260	-0.6230	0.7820	-0.744

Table 5 – The normalized variables and the value of I^{2016}

Indicator	**Scania**	**Paccar**	**Ashok Leyland**
C_1	0.265	0.425	0.705
C_2	0.561	0.691	0.608
C_3	0.143	0.401	0.253
C_4	0.955	0.859	0.750
C_5	0.537	1.000	0.682
C_6	0.499	0.619	0.558
C_7	1.000	0.686	0.819
C_8	0.889	0.895	0.918
C_9	0.446	0.510	0.673
C_{10}	0.524	0.567	0.735
C_{11}	1.000	0.869	0.532
C_{12}	1.000	0.842	0.739
C_{13}	1.000	0.842	0.362
$\boldsymbol{I^{2016}}$	**7.102**	**6.979**	**6.482**
Ranking	1	2	3

Conclusion

Theoretically, this paper contributes to current literature in the field of performance measurement with a new composite indicator of company performance.

1) The conceptual framework is new and transparent, with seven dimensions and thirteen indicators, including three environmental indicators, based on released figure rather than subjective judgements;

2) methods during phase II to phase IV is new and is with appropriate assumptions for truck manufacturers.

Practically, the composite indicator derived from the method can serve as an informative statistical tool to enhance their decision-making capability by showing manufacturers' multidimensional performance.

This approach developed can better overcome the 9 cons in table 1. For the further research, 1) for a time series analysis, data from more fiscal years needs included, which might involve concerns about data preprocessing, such as data imputation and data inconsistency; 2) robustness and effectiveness of method developed needs being conducted by a post analysis; and 3) detailed discussion about benchmarking companies considering the outcome of the composite indicators needs analyzed.

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