A CONCEPTUAL FRAMEWORK OF WEIGHTED MODIFIED OVERALL VEHICLE EFFECTIVENESS.

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ABSTRACT
Purpose: This paper aims to improve the original Modified Overall Vehicle Efficiency (MOVE) to make it become more appropriate in different perspective in each industry. MOVE can be helpful for monitoring and measuring vehicle performance for road freight transportation. To achieve this effectively, this paper proposed a newly calculating methodology by using a simpler weight setting method in every single elements of MOVE model.

Design/methodology/approach: First, literature review of vehicle performance measurement and weight setting method are conducted. Second, the suitable measurement tool are selected for interested industry to adapt the formula to be more appropriate. Finally, the proper weighting method are added into the calculating formula to make it fit for industry goal.

Findings: This paper shows list of tools that developed from Overall Vehicle Effectiveness (OVE) and weighting method used in similar measurement.

Research limitations/implications: (if applicable): This paper only focused on OVE based measurement tool and none complicated weight setting method to make it easier for the industry to be implemented.

Practical implications: (if applicable): The proposed of this modified model will allowed industry to be able to measure the specific interested measurement by combining the appropriate tool for their interesting.

Originality/value: This conceptual framework shows the newly calculating method combined the traditional MOVE approach with the weighted MOVE approach. This can solve the problem of MOVE which is each element in model are not equally important, the different weight in each element in MOVE model should be taken into account to increased effective of measurement.

Keywords: Modified Overall Vehicle Effectiveness, Rank Order Centroid, Combined Series and Parallel Systems, Transport, Performance Measurement.

Introduction

In recently, performance measurement is become more an important in several business companies. Due to the companies are now facing a competitive environment, this has pushed the companies attempted to enhance the effectiveness and efficiency in their company. Performance measure is the process of quantifying the effectiveness and efficiency of a past action (Neely et al., 1995). Effectiveness is a succeed of met customers' requirement and efficiency is how economically a firm's resource are utilised. Moullin (2002) also defined the definition as a tool that evaluating how well of organised are managed. As the mention, Efficiency failure and leads to more information decision making regard to chain design. Performance measurement is a tool to identify opportunities for progressive improvement in process performance (Wegelius-Lehtonen, 2001). Therefore, the definition of the performance measurement can be defined as a process of evaluating of the effectiveness and efficiency utilise on people, resource and technology and also how well organisations are managed. The knowledge of the company performance can help improve overall business capacity can enhance understanding.

Logistics is playing an increasing a important role in business. Therefore, it is important for organisation to manage their vehicle performance to successfully deliver customer requirement in an effectiveness. Many organisation are seeking to improve their operations to meet the demand on transportation which mainly is faster delivery, higher accuracy, greater flexibility, lower cost and not damage delivery. Company have also to increased profits. Having own private fleet indeed gives company many advantage but there are also the disadvantage sides that company has to deal with such as fixed cost in vehicle purchasing cost, maintenance cost, labor cost and so on. This is the reason why company must be aware of.

OVE method aims to develop an operation measure of transport efficiency and to contribute to the way in which the road freight transport industry is measured and benchmarked (Simon et al., 2004). This method can be also considered as one of the primary model for vehicle performance measurement. Many in the past decade has paid attention on this model and develop the concept into their own interested idea. However, OVE still has some weakness point due to different perspective on each industry that lead to the importance of adding weight on each single elements of the model to eliminate its own weakness.

This paper would like to proposed a model for the company that has cost dimension and round-trip problem interested which suit the concept of MOVE, a modified of OVE. Adding weighting method on each MOVE elements would make a model appropriated for the case study in the future work which is Royal Project Foundation, in Thailand.

<u>Literature review</u>
The literature review base on the three primary objectives, to understand the evolution of MOVE which is base on OVE, identify weighting method and the concept of combined series and parallel system of reliability function.

Evolution of MOVE

Model	**Overall Vehicle Effectiveness (OVE)**	**Modified Overall Vehicle Effectiveness (MOVE)**	**Transport Overall Vehicle Effectiveness (TOVE)**	**Overall Transportation Effectiveness (OTE)**
Author	Simon et al. (2004)	Guan et al. (2003)	Villarreal (2012)	Dalmolen et al. (2013)
Develop from	OEE	OVE	OVE and Value Stream Map (VSM)	OEE and OVE
Formula	<u>OVE(%) = Availability (A) x Performance (P) x Quality (Q)</u> : all of components expressed in unit of tonne-km and percentage. **A:** Actual operating time divided by plan operating time **P:** Operating speed rate multiply by Net operating rate. **Q:** Good successfully delivered divided by Total of goods delivered.	<u>MOVE(%) = Vehicle utilization (V) x Route efficiency (R) x Time efficiency (T) x Quality (Q)</u> : all of components expressed in unit of tonne-km and percentage. **V:** Required capacity divided by Available capacity. **R:** Minimum route cost divided by Actual route cost **T:** Shortest possible time on best possible route divided by the Actual time taken.	<u>TOVE(%) = Administrative availability efficiency (Adm.) x Operating availability efficiency (Optg.) x Performance efficiency (P) x Quality efficiency (Q)</u> :all components are expressed as percentage. **Adm.:** Available for route divided by calendar time. **Optg.:** Available in transit divided by Available for route. **P^2:** Capacity efficiency divided by available in transit.	<u>OTE(%) = Availability (A^3) x Performance (P^3) x Quality (Q^3)</u> : all components are expressed as percentage. **A^3:** The real driving time for truck drivers divided by the period that orders can be scheduled and executed, transport is available or other transport activities. **P^3:** The real time operation driving time divided by

		Q: Goods successfully delivered divided by Total goods to be delivered.	**Q:** Capacity efficiency minus quality loss (%) divided by capacity efficiency.	real running time. **Q³:** Time that orders are executed on-time divided by used time.
Characteristic	•OVE does not reflect to the optimal fuel efficiency. (W) •Round trip problem in OVE. (W)	•Round trip problem does not occur. (S) •MOVE might not be able to give the optimal solution when considering the overall fleet performance which involves in more than one vehicle . (W)	•TOVE can be use only which own private fleet of transportation vehicles due to the calendar time consideration. (W)	•OTE is more detailed in identifying losses for LSPs and provides solutions to the efficiency round trip problem. (S)
Previous implementation	Mustaffa (2009) used OVE and MOVE to determine the total cost in the periodic “can-deliver” of Inventory Route Problem (IRP) model.		Villarreal et al. (2013) applied TOVE and VSM to carried out in the routing operation of bottled beverage in Mexico by identify and eliminate specific waste associated with the transportation of goods to improve its efficiency.	

Table 1. The evolution of OVE
Source: Compiled by the Author.

The table 1 is shown the list of tools that has been developed from OVE which is included namely, author, formula, characteristic and previous implementation. Nakajima (1998) propose the Over Equipment Effectiveness (OEE) as a tool for measures machine performance in manufacturing which is based on three main aspects which is Available Rate (A^1), Performance Efficiency (P^1) and Quality Rate (Q^1), each element concerns which the different losses via benchmarking technique. Simon et al. (2004) was adapted the concept from OEE to OVE. OVE is developed form the holistic measuring the effectiveness of transport operations from the proportion of value-added activities in transport operation unlike other transport measure, such as Vehicle Utilization and Energy Efficiency Measuring (McKinnon, 1999). OVE used the three aspects of OEE are applied to benchmark the total performance of vehicle effectiveness expressed in the units of weight-distance (tonne-km). Manson et al. (2001) converted six big losses in manufacturing which is equipment failure or breakdown loss and set-up (and adjustment losses) in A^1, idling (and minor stoppage losses) and reduced speed losses in P^1 ,and defect (and rework losses) and start-up losses in Q^1 to the five big losses of OVE in table 2. OVE aims to reduce these five loose activities by using lean thinking approach and it is useful when determining area for potential improvement. Table 2 shows the losses are defined as the five big losses in OVE and definitions are described as follows:

Performance aspects	Relating losses	Definition
1. Availability	Driver breaks	Statutory breaks taken during a journey are considered a loss. If the statutory break is taken at the end of a journey or when somebody else is loading/unloading then it is not a loss.
	Excess load time	A standard time is allowed to load and unload a

		vehicle. When loading/unloading exceeds the standard time, for reasons outside the control of the vehicle driver, then excess load time occurs.
2. Performance	Fill loss	Ideally the vehicle will be full; either by weight or volume, whichever is the lower constraint. Fill loss occurs when the vehicle is not fully loaded.
	Speed loss	Ideally the vehicle will be full; either by weight or volume, whichever is the lower constraint. Fill loss occurs when the vehicle is not fully loaded.
3. Quality	Quality delay	Goods damaged in transit or poor/invalid paperwork would both be examples of quality issues that impact adversely on the OVE measure.

Table 2. Performance aspects of OVE and relating losses adapt from Simon et al. (2004).

However, OVE has faced the round-trip when case is multiple destination, which OVE gives a higher value to lower efficient route (Guan et al., 2003). Due to OVE consider the alternative of carrying goods in longer distance as higher value-adding to the end customer while it is obvious that this alternative is less fuel efficient then less effective (Guan et al., 2003). Therefore Guan et al. (2003) attempted to developed MOVE to solve this problem which provided a better fit to characteristics of transportation and also the sensible objective of performance metrics of transportation operation.

MOVE is a method is to measuring a single vehicle for road transport. To be able, MOVE to reflect the efficiency route Guan et al. (2003) was added a factor of minimum route cost or route efficiency into the equation so that the round-trip problem can be overcome. MOVE was dividing the performance factor into two components which is route and time efficiencies. The four aspects concern of MOVE metric are:

- <u>Vehicle Utilization</u> or Vehicle Available in OVE is the ratio of the minimum route cost and the available capacity. It is based on available capacity and required capacity.
  Available Capacity = Maximum Load x Distance
  Required Capacity = the minimum route cost
- <u>Route Efficiency</u> is the ratio to evaluate the efficiency of route. The ratio is between the actual route for shipment against the most efficiency route which is minimum route cost.
- <u>Time Efficiency</u> is the ratio between the actual time taken for a vehicle to complete the shipment against "the shortest possible time" required for that vehicle to complete all value-added activities for that shipment. It requires two components which is shortest possible time and actual time taken.
  Shortest Possible Time = Time taken assuming the optimal speed + Statutory break
  Actual Time Taken = Travel Time + Unloading and loading Time + Queue Time + Break Time + Break Time – Break taken while loading and queuing
- <u>Quality</u> is unchanged from OVE. The ratio of the goods which are delivered to the customer within promised conditions, without any damage or losses against the total goods delivered.

Next, Villarreal (2012) developed tool based on OVE which is TOVE. TOVE is a modified overall vehicle efficiency measurement that aim to measured its effectiveness. Start with vehicle waste identifying with VSM approach then combined TOVE and VSM, it calls Transportation Value Stream Map (TVSM). Dalmolen et al. (2013) create OTE based on OVE to measure efficiency of Logistics Provider Services (LPS).

Weighting method

In 1994, Raouf introduced weighting method of OEE. This methodology assigns weights to three elements of OEE which is A^1, P^1 and Q^1 but the paper did not shows how to setting the weight. Raouf (1994) assumed that A^1 has a weight of k_1, P^1 has a weight of k_2 and Q^1 has a weight of k_3 where $0 \leq k_i \leq 1$ and sum of k_i must be equal 1. This is called Production Equipment Effectiveness (PEE) and can calculated as:

$$PEE(\%) = (A^1)^{k_1} \times (P^1)^{k_2} \times (Q^1)^{k_3}$$

Raouf (1994) was states that this method is an effective tool to enhancing the capital productivity by effective controlling the maintenance systems. The different weight setting of each single element has proved to be more reasonable than the original OEE, as importance in each element is different (Raouf, 1994). Wudhikarn (2010) also designed the Overall Weighting Equipment Effectiveness (OWEE). OWEE proposes a simpler weight setting method which Rank-Order Centroid (ROC) to identify different weight in each element of OEE. Whudikarn (2010) mentioned that ROC methodology is easy method for company to collected the weight by interviewing a top manage who has a total authority of the company of the company management. ROC is a method that proposed by Barron and Barrett (1996). This technique would like to give more relative weight important to the highest ranked attribute and less relative weight important in exponential differentiation not linear (Roszkowska, 2013). The calculating formula of the ROC is defined as:

$$W_i = (1/K)\sum^{K}_{j=l} 1/r_k$$

Where r_k is the rank of the k^{th} objective, K is the total number of the objectives, and W_i is the normalized approximate ratio scale weight of the i^{th} objective.

Then, the Overall Weighting Equipment Effectiveness (OWEE) is calculated as the following formula (Wudhikarn, 2010).
$OWEE(\%) = w_A A^1 + w_P P^1 + w_Q Q^1$
Where w_A is the weight of the A^1, w_P is the weight of P^1 and w_Q is the weight of Q^1.

Wudhikarn (2010) also compared the original OEE, Raouf's OEE and OWEE method, the result from original OEE is different from Raouf's OEE and OWEE which are almost similar.

Basic Elements of System Reliability

According to Myers (2010) suggested the basic principles and function relationship used for reliability assessment of systems with simple interconnections by using mathematic function. The reliability. The system reliability is defined as its ability to react within a specified time during an operation period (Lisnianski and Levitin, 2003). The reliability systems consist of the series systems, the parallel systems and the combination series (Myers, 2010). The physical connection among elements represented by a series reliability block diagram, its can differ as well as their allocation along the system's functioning process. The series system operationalize depends on all its elements operationalize (Lisnianski and Levitin, 2003) as figure 1.

Figure 1. Block diagram for elements in series.

The Figure 1. Shown the reliability of the system made up of elements P_1, P_2 to P_n, It is the probability that all elements are operational. Where P_i represent the respective reliability of element P_1 to P_n. This relationship should made clear that the calculation is easily calculated as:

$$R_S = \prod^{n}_{I=1} P_i$$

Where R_S represents the total reliability of the systems that comprises component P_i to P_n.

The parallel systems is a system that composed of element P_1 and P_2 and it is operational if either element or both elements are operational as shows in Figure 2.

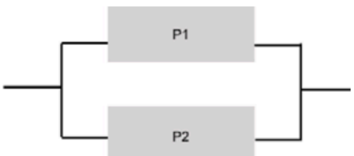

Figure 2. Block diagram for elements parallel.

The general relationship for a system of n components arranged in parallel is

$R_p = 1-\prod_{i=1}^{n} (1-p_i)$

Finally, to combine the all element in series and parallel as figure 3.

Figure 3. System with element in series and parallel.

The formulation will be as follow:

$R_P = P_1(1- (1- P_2)(1- P_3))P_4$

Methodology

In the light of the above, the selected model is MOVE due to its ease of use that easy, not too complicated and cover most of interested area for the company in future case study which Royal Project Foundation in Thailand as agricultural business who focused on quality of good, cost and delivery time for their vehicle usage in both own private vehicle and outsource.

After done selecting vehicle performance measurement tool, this paper uses the ROC weighting method that suits with the selected case study due to its easiness. The case study company has to give rank order on importance of attributes in MOVE which is V, R, T and Q. Relative important weight for the 1st to 4th will be 0.52, 0.27, 0.15, 0.06 respectively, no matter what each attribute ranking is placed according to the rule and formulation of ROC.

Table 3. shows the prioritized order and result weigh of each element by using the ROC method. This paper assume the weight of each element as shown in table 3.

Element	Ranking	Numerical calculation	Weight
V	4	$W_V = (¼)⁄4$	0.06
R	3	$W_R = (⅓+ ¼)⁄4$	0.15
T	2	$W_T = (½ + ⅓ +¼)⁄4$	0.27
Q	1	$W_Q = (1 + ½ +⅓+ ¼)⁄4$	0.52

Table 3. Weight setting by ROC method.

The newly calculating method combined the original MOVE approach with the weight setting by ROC method are calculated by concept of reliability function from Myers (2010) arranged in combined series and in parallel systems. In this paper, the element in parallel is a system that composed of MOVE elements which is V, R, T and Q ,with the weight of element. Myers (2010) suggested that the parallel system consists of 2 operational functions can be combined together as the following equation:

$$R_p = 1-\prod_{i=1}^{n} (1-p_i)$$

Where p_i represent the reliability of element i and R_p is represent the reliability of the system that compose of n element. Therefore, the adaptation of the proposed said model with MOVE, ROC and the parallel system can be formulated as:

$V_w = 1-(1-V)(1-w_V)$
$R_w = 1-(1-R)(1-w_R)$
$T_w = 1-(1-T)(1-w_T)$
$Q_w = 1-(1-Q)(1-w_Q)$

Where V_w, R_w, T_w and Q_w is V, R, T and Q including weight of each element from table 2.

Finally, the value of V_w, R_w, T_w and Q_w are combined by multiply each value together as the rule of combined series which similar to the original MOVE as:

$$\text{Weighted MOVE}(\%) = V_W \times R_w \times T_w \times Q_w$$

Discussion
This part of research will discuss based on three objective, first is weighting method, second is each formulation implication and the last is result of MOVE in each formula.

In weighting method, ROC is the easy method for company to understand and easy to calculate, However, in some case of company where relative weight important of some element are equal, ROC may not be able to reflect the different and determine the appropriate weight which is supposed to be similar (e.g. decision maker can not decide which element is more important). Analytical Hierarchy Process (AHP) are suggested to use instead ROC but the process of AHP should be clear explain to make should that company understand its process correctly due to complicatedness of the tool itself.

For the calculated formula, the original MOVE does not reflected interesting on each element of MOVE model which is reflect to prioritize the problematic of vehicle performance for the company. However, the approach of Wudihikarn's method also not reflect to the overall of performance due to the formula which is sum all of element that including weight, this means each element are not related. For Raouf's method is appropriate due to the multiplication of each element that reflect the relation in mathematical term. But, the result does not reflect the realistic of the performance that will discussed

Table 4. Show that results of four method which assume that 40% of Vehicle Utilization, 80% of Route Efficiency, 70% of Time efficiency and 40% of Quality Rate are all expressed in unit of tonne-km, with weight from table3.

Model	Formula	Result (%)	Weight
Original MOVE	MOVE = V x R x T x Q	20.16%	
Raouf's method	MOVE = $V^{w(v)} \times R^{w(r)} \times T^{w(t)} \times Q^{w(q)}$	54.1%	✓
Wudhikarn's method	MOVE = $W_V V + W_R R + W_T T + W_Q Q$	53.76%	✓
Weighted MOVE method	MOVE = $V_W \times R_w \times T_w \times Q_w$	20.12%	✓

Table 4. Numerical results of MOVE from four methods

From table 4., the results from those four different method have been calculated and outcomes are represented in percentage. The result of the original MOVE is 20.16% because the original formulating keep multiplying percentage of each element, it will result in less and less finalize value. However, the calculated value of Raouf's method and Wudhikarn's method which is similar to each other are much different from the original MOVE due to the nature of power weight with less than one that will result in a higher number in case of Raouf's method and the summation of value that give more and more value in case of Wudhikarn's method. As the formulation in MOVE, the relative weight of each element are equally important but in table 3. this paper assume the highest weight important is belong to the lowest value which is 40% in quality, the outcome on other model should give a lower result that the original MOVE but the actual calculation of Raouf's and Wudhikarn's give a higher outcome which is contrast to what it should be.

The newly calculation of MOVE shown the result which is 20.12% is close to the original MOVE with less value than the original as it is supposed to be due to the unimportant element got the highest performance percentage. Therefore, the wighted MOVE is more accurate and appropriate method than the other two method that including weight and also the original MOVE as in table 4.

Conclusion
The aim of this research is to improve MOVE model for more appropriately measuring vehicle effectiveness in company and satisfy what the company need. The four elements of MOVE which is Vehicle Utilization, Route Efficiency, Time Efficiency and Quality Rate is still unchanged from MOVE. However, the equation is integrated with weighting method in measurement. All the element affecting

weighted MOVE are not equally important in all industry and as such different weights should be established using ROC which is an easy and accurately technique for decision makers. Afterward, using the concept of combine series and parallel system of Reliability Function to formulate newly equation of MOVE in percentage.

Future work

The future work will be able to adapt the weighted MOVE model into agricultural business in Thailand which is Royal Project foundation. Finding should determine the interested topic for the specific company to adjust the weight for the model and the calculating formulation used in the model should be modified in order to make it fit with particular company limitations. Furthermore, the formulation in the model should be modified in order to measure the whole fleet, not only just a single vehicle. Lastly, the characteristic and behavior of the particular industry should be investigated deeply to understand more in model modification.

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