Trends in Bioinformatics

ISSN 1994-7941

OPEN ACCESS Trends in Bioinformatics

ISSN 1994-7941
DOI: 10.3923/tb.2016.65.69

Research Article
Modelling the Road Transport for Efficiency Analysis

[1]Zailani Bin Mohd. Zaid, [2]Muhammad Zaly Shah and [1]Azlin Bt. Abdul Rahim

[1]Malaysian Institute of Aviation Technology, Universiti Kuala Lumpur, Lot 2891, Jalan Jenderam Hulu, Dengkil, Selangor, Malaysia
[2]Fakulti Alam Bina, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia

Abstract
Road transportation system is a complex series of activities. However, this can be broken down into sub-activities for easier understanding to analysis its efficiencies. This study discusses a simple technique of process mapping to develop a simple model for efficiency analysis of road transport specifically container haulage system. Observation was made in the industry, processes are then mapped for model development. Basic variables are then identified after which the model are developed for further analysis of efficiency.

Key words: Transport, road transport, container haulage, modelling, process mapping, data envelopment analysis

Received: April 20, 2016 Accepted: June 29, 2016 Published: September 15, 2016

Citation: Zailani Bin Mohd. Zaid, Muhammad Zaly Shah and Azlin Bt. Abdul Rahim, 2016. Modelling the road transport for efficiency analysis. Trends Bioinform., 9: 65-69.

Corresponding Author: Zailani Bin Mohd. Zaid, Malaysian Institute of Aviation Technology, Universiti Kuala Lumpur, Lot 2891, Jalan Jenderam Hulu, Dengkil, Selangor, Malaysia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

This study will focus on the development of the model to analyse the efficiency of the road transport with possible application in container haulage. This empirical examination is done on Malaysian container haulage industry. Modelling the road transport is the initial step towards its efficiency analysis. This approach involves examining the activities in the industry, understanding the industry process and map it to develop the model for efficiency measure. This model can then be validated by testing it using the actual data collected from the industry.

MODEL DEVELOPMENT

The step involves developing the basic model for container haulage, operational analysis, mapping the operations into a logical process flow and identifying the variables. Modelling is based on the application with Data Envelopment Analysis (DEA) for efficiency analysis. In establishing the research construct, the operational analysis are carried out on the container haulage industry to gain understanding and hence to have a framework of the container haulage system. The container haulage system is represented by the following Basic Container Haulage Model (Fig. 1).

Figure 1 represent the function of the hauliers, basically the respective container haulage companies, where these companies form the unit of analysis in this study, called Decision Making Units (DMUs). The hauliers, represented by Haulier 1, Haulier 2 and so on, haul the containers from the seaports, represented by Port 1, Port 2 and Port 3. The containers are then sent to the factories, represented by Factory 1, Factory 2 and so on. This is the case of import containers. As for the case of export containers, the hauliers will haul the containers from the factories to the seaports for onward shipment to respective destinations. From here, it is clearly seen that the main production output of the container haulage system is the number of containers carried by the container haulage companies. This production volume, that is the number of containers carried, is measured in twenty-foot equivalent unit (TEU), where one 20-foot containers is equivalent to 1 TEU and one 40-foot container is equivalent to 2 TEUs.

In the container haulage system, sea port is the terminal where road transportation segment of container haulage either originates or terminates. This is the connection point between road transportation and sea transportation in the wider scope of container transportation.

The factory in the above framework denotes primarily the manufacturing facilities who manufacture the goods for export. For the purpose of this study, it also denotes the exporter or importer in general, as a diagrammatic representation of operations analysis to aid the understanding of container haulage system. It is the originating or terminating points for export or import, respectively.

From this framework as presented in Fig. 1, a more detailed processes of the container haulage system are mapped into a logical process flow and presented in the Fig. 1 to reflect the actual operations of container haulage. In process mapping, observations are made on the operations of container haulage in the industry. For this study, four selected container haulage companies, viz., Kontena Nasional Berhad, MISC Haulage Services Sdn Bhd, Multi-Modal Freight Sdn Bhd and Konsortium Logistik Berhad are observed. The selection is based on the establishment and organization of the companies, to ensure minimal problems concerning data availability and reliability. From these observations, the processes are then mapped into process flow chart to represent the actual processes that reflects container haulage functions and operations.

In Fig. 2, the container haulage processes as a whole cuts across the functions of several agencies/organisations viz., factories (exporters and/or importers), forwarding agents, the container haulage companies (haulier), which is the subject of the investigation of this study, customs and port authorities (port operators).

For import cargo, the importer (represented by factories as in the Fig. 1) will get the services of forwarding agents for the services to handle the shipment of the cargo. With the import documents, the forwarding agents will request for transport services from the container haulage companies

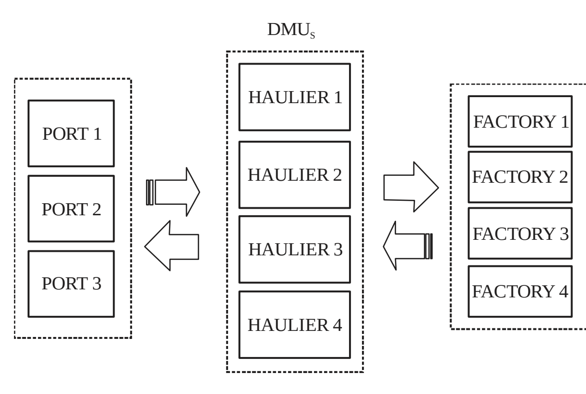

Fig. 1: Basic container haulage model

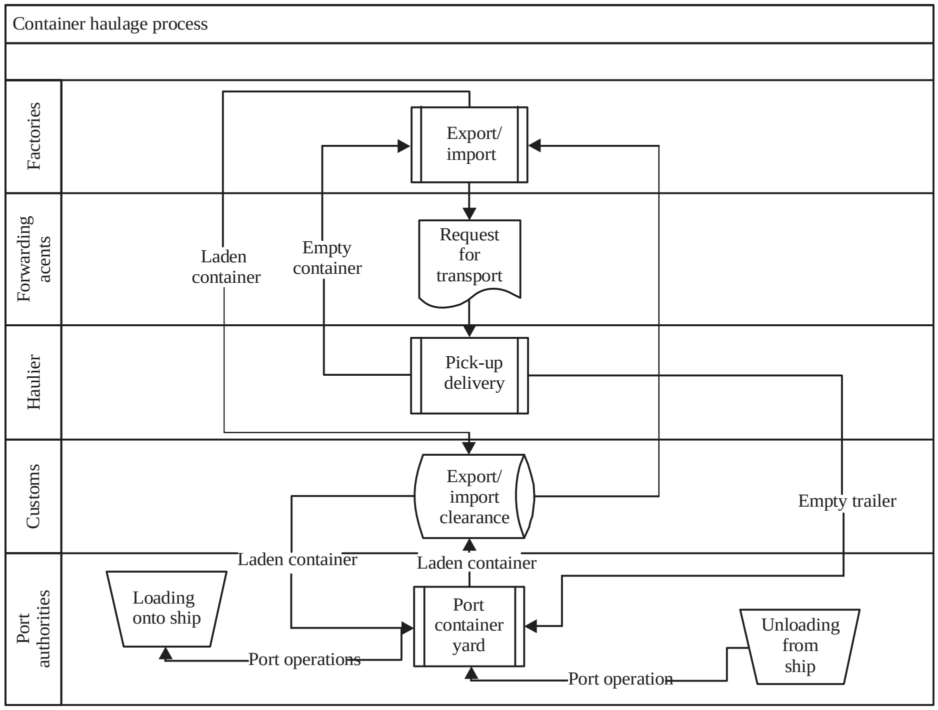

Fig. 2: Container haulage process

(haulier) for the transportation of the container from the port. The forwarding agents will also submit the importation documents to the customs for clearance. Once the port authorites/operators unload the containers from the ship, the container haulage companies will pick up the containers from the port and cleared by the customs, after which, the containers are sent to the importers.

As for the export cargo, the exporter (represented by factories in Fig. 1 will prepare the documentation for the shipment of the containerized cargo. The services of forwarding agents are obtained to handle the shipment and the forwarding agents will send the request for transportation services to the container haulage companies. The container haulage companies will then pick up the containers and haul it to the port, whereas the forwarding agents will do the customs clearance before the containers being hauled to the port. Once cleared by customs, the port authorities will load the containers onto the ship for transportation to the destinations.

From the basic container haulage model developed as presented in Fig. 1 and detail processes of container haulage operations are presented in Fig. 2, possible variables for efficiency analysis are then identified. In modeling the processes, Hackman *et al.*[1] specified the input and output variables to enable the analysis of the processes.

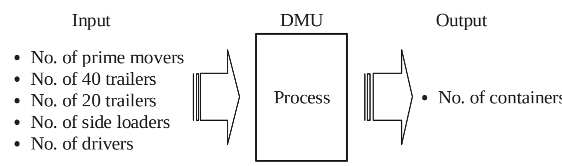

Fig. 3: Container haulage input and output

From the basic container haulage model in Fig. 1 and the container haulage process in Fig. 2, the input and output specifications for the container haulage are then modelled as in Fig. 3.

Figure 3 represents container haulage activities with some possible input variables and output variable, that is the number of containers hauled, measured in twenty-foot equivalent units (TEUs). This output variable is the single primary production output out of container haulage activities.

For efficiency analysis of container haulage industry in Malaysia, one of the most suitable DEA model has to be administered. This is done by some guiding principles in selecting the most suitable DEA model for the purpose of this study.

From the review of literatures and observations made on the Malaysian container haulage industry to determine its characteristics, the input oriented CCR model (CCR-I) of Data Envelopment Analysis is chosen. This choice is based on the following justifications and assumptions:

- The CCR evaluates scale as well as technical inefficiencies simultaneously[2]. This is important feature of the chosen model to address the particular characteristic of Malaysian container haulage industry with different scale sizes among the Decision Making Units (DMUs), while at the same time evaluating the technical inefficiencies of the DMUs
- Input oriented CCR model is more appropriate to address the problem in the container haulage industry in Malaysia, where input-oriented model aims at reducing the input amounts by as much as possible while keeping at least the present output levels. This is warranted by the effects of liberalisation of Malaysian container haulage industry, where the haulage companies have added significant investments in resources. This is in line with one of the suggestions put forth by Cooper *et al.*[2] where one of the criterions in the choice of model is whether the focus is on input or output oriented
- It is assumed that constant returns-to-scale prevails at the efficient frontiers, where Cooper *et al.*[2] pointed out that the proportional increase in input will lead to proportional increase in output. This is further supported by the following statement by Cooper *et al.*[2]:
    - In addition to treating multiple outputs and inputs simultaneously it is necessary in DEA to allow for cases in which constant returns-to-scale prevails over an entire region
    - The measurement of efficiency in Constant Returns to Scale (CRS) for the container haulage companies is attained via N linear programming problems in Charnes *et al.*[3] as:

$$
\begin{aligned}
&\mathrm{Min}_{\psi,\lambda}\ \psi_j\\
&\textstyle\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j;\ r=1,..,R\\
&\textstyle\sum_{i=1}^{N} \lambda_i y_{si} \leq \Psi_j x_j;\ s=1,..,S\\
&\lambda_i \geq 0;\ \forall i
\end{aligned}
$$

where, $y_i = (y_{1i}, y_{2i}, ..., y_{Ri})$ is the output vector, $x_i = (x_{1i}, x_{2i}, ..., x_{si})$ is the input vector. The above equation solves for every sample of the N container haulage companies, N weighs and N optimal resolution gathered. Each optimal resolution ψ_j^* is the efficiency indicator of the container haulage company j and, by construction satisfies $\psi_j^* \leq 1$. Those container haulage companies with $\psi_j^* < 1$ are considered inefficient and $\psi_j^* = 1$ are efficient.

Figure 4 shows that subsequent to data collection a 'Skeletal model' is developed on the basis of input-oriented CCR data envelopment analysis model (CCR-I). This 'Skeletal model' uses three input variables which comprise of prime mover, 40 foot container trailer and driver. Data is run using DEA-Solver Pro8.0 and the results are analysed to determine the functionality of the 'Skeletal model'. The results are acceptable when the 'Skeletal model' is able to discriminate between the efficient and inefficient Decision Making Units (DMUs), that is, the container haulage companies under investigation. If the 'Skeletal model' is not able to discriminate between the efficient and inefficient DMUs, the 'Skeletal Model' will be reviewed and other possible input variables will be tested until the 'Skeletal model' can identify the efficient and inefficient DMUs. This is the iterative process in this model development stage.

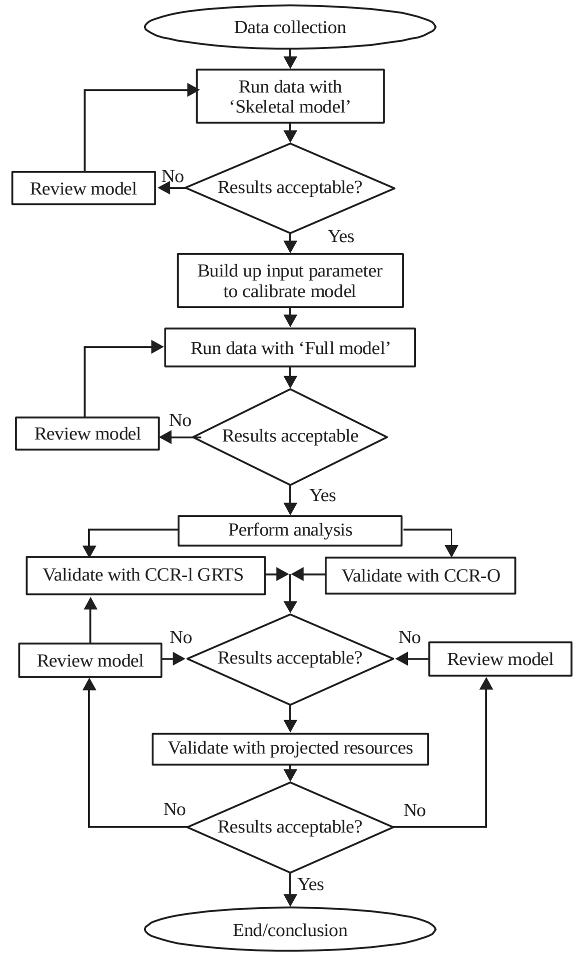

Fig. 4: Model development process

Figure 5 is a 'Skeletal model' developed for the container haulage industry for application with Data Envelopment Analysis for relative efficiency measurement. This 'Skeletal model' is to test the functionality, applicability and suitabality of the model for industry applications by using the actual data gathered from the industry. In terms of functionality, the

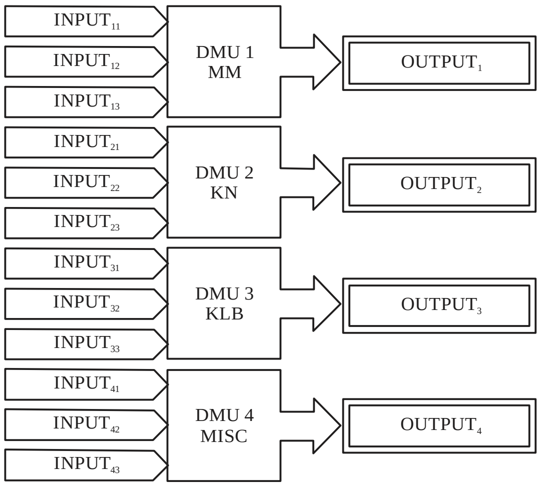

Fig. 5: Skeletal model for container haulage industry

model is acceptable when it is able to discriminate between the efficient and inefficient Decision Making Units (DMUs) and able to show the level of relative efficiencies of DMUs.

In this 'Skeletal model', INPUT_{11} represents input variable 1 for DMU_1, INPUT_{12} represents input variable 2 for DMU_1 and INPUT_{13} represents input variable 3 for DMU 1. The same logical sequence is applied to the rest of DMUs under observation. These input variables are prime mover, 40 feet container trailer and driver for respective Decision Making Units (DMUs) under observation, represented by DMU 1, DMU 2, DMU 3 and DMU 4, to represent Multi-Modal Freight Services Sdn. Bhd., Kontena Nasional Berhad, Konsortium Logistik Berhad and MISC Haulage Services Sdn Bhd. to produce the respective outputs for the DMUs represented by OUTPUT_1, OUTPUT_2, OUTPUT_3 and OUTPUT_4, respectively. This output is the output of the production processes for the container haulage industry, which is the container volume (number of containers carried) measured in 20 feet equivalent units (TEUs).

The 'Skeletal model' is then build up further by adding the input variable as suggested by Cooper *et al.*[2]. Another input variable, the 20 feet container trailer is added to the initial 'Skeletal model' to form the 'Full model'. This 'Full model' is also used to calibrate the model developed in order to have a more precise model for the container haulage industry that can be used to compute its comparative efficiency while at the same time to reflect the actual operating environment in the industry. Data is then run using the DEA-Solver Pro8.0 with this 'Full model' to see its effect on the Decision Making Units (DMUs). The results are evaluated and if the 'Full model' is able to discriminate between the efficient and inefficient DMUs, it is acceptable and meet its objective in comparing the efficiencies of the container haulage companies. Otherwise, the 'Full model' will be reviewed and tested with other possible input variables until the results are acceptable for comparative efficiency computations.

CONCLUSION

To evaluate the efficiency of road transport, firstly understanding the processes is very critical. From this understanding, the processes can then be mapped into logical mathematical model which can then be developed to analyse the efficiency. The input and output variables must be identified to form the constructs after which the model can be tested with the real data from the industry.

This basic technique can be adopted for possible applications in all processes that need efficiency analysis.

REFERENCES

1. Hackman, S.T., E.H. Frazelle, P.M. Griffin, S.O. Griffin and D.A. Vlasta, 2001. Benchmarking warehousing and distribution operations: An input-output approach. J. Prod. Anal., 16: 79-100.
2. Cooper, W.W., L.M. Seiford and K. Tone, 2006. Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software. Kluwer Academic Publishers, USA.
3. Charnes, A., W.W. Cooper and E. Rhodes, 1978. Measuring the efficiency of decision making units. Eur. J. Operat. Res., 2: 429-444.