TRANSPORTATION MODEL IN DELIVERY GOODS USING RAILWAY SYSTEMS

Fauziah Ab Rahman
Malaysian Institute of Marine Engineering Technology
Universiti Kuala Lumpur
Lumut, Perak, Malaysia
fauziahabra@unikl.edu.my

Siti Nurhafiza Ahmad
Malaysian Institute of Marine Engineering Technology
Universiti Kuala Lumpur
Lumut, Perak, Malaysia
fizamuiz_30062013@yahoo.co.uk

ABSTRACT

Every organization set up to achieve goals and objective in the most low cost and high-profit manner. One of the techniques that can assist the manager of business organizations in this regard is operational research. The operational research is a scientific approach to the basic structure, characteristic of an organization to provide the method in solving the transportation problem. It also as a tool for making the decision in any operation and scheduling. In Ipoh Cargo Terminal (ICT) case, they operate in delivering goods by ships and trains. Focus of the research is railway line involved in the operation. If the railing schedule is not properly, they cannot minimize the cost. For instance, when they have a delay in the operation, the result is more money will be used to guarantee all operation run smoothly. The study aimed to investigate the trend of fees or cost involved in delivering goods using railway lines at ICT. It is included the information of the rate charges and additional accusations of a container ship for the customer, shipping line, maritime transport agencies, freight forwarder, forwarding agent, and haulier. The study also focused on the calculation of net delivery cost occurred from ICT to Port Klang, West Port, and North Port. The research shows that the best method to minimize the cost and gained profit in delivering goods between ICT, Port Klang, West Port and North Ports is Vogel's Approximation Method (VAM). It shows Vogel's Approximation Method can minimize the total delivery cost less than 3.72% from Least Cost Method and less than 17.45% from Northwest Corner Method.

Field of Research: *Operation Research, Transportation Method, Railway System, VAM*

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1. Introduction

Transportation model is a particular class of the linear programming problem. It deals with the situation in which a commodity is shipped from sources to destinations. The transportation problem is one of the earliest and most important applications of linear programming problem (Debashis and A. Satyanara, 2010). Then the operational research is the application of scientific methods to the problem arising from the operation involving integrated of the system of men, machines, and materials. In the general, the transportation model can be extended to areas other than the direct transportation of a commodity, including among others, inventory control, engineering and technology, management science, employment scheduling and operation in shipping industry (Salami, 2011). It is one of the fundamental problems of network flow which is usually used to minimize the transportation cost for industries with the number sources and number of destinations

while satisfying the supply limit and demand requirements (Muhammad, 2012).

It was first studied by F.L. Hitchcock in 1941, then separately by T.C. Koopmans in 1947, and finally placed in the framework of linear programming and solved by the simplex method by G.B. Dantzig in 1951 that show in the studied by Muhammad K.H. in 2012. Since that, many researchers have improved the methods as well as new solutions have been developed, showing that the application is still expanding. Due to its development and adaptability to the current process, this method is without a doubt a very reliable one. Furthermore, several methods have been established to find the most optimal solution. The methods containing in transportation model are Vogel Approximation Method (VAM), Least-Cost Method and more. The methods aim is to find a solution on how to minimize the cost, sources, and the destination they are heading. Nowadays, many of the shipping schedules does not emphasize on reducing the cost when they operate. It is due to the competitive advantage in the shipping business.

Therefore, methods that will be used in this research are the Vogel's Approximation Method, Least – cost Method and Northwest Corner Method. It was selected to achieve the objective of research. With these methods, the researchers will know how to make the scheduling of employments; inventory control and personal assignment will not be delayed when the ship or train is under operation. Moreover, this research shows the possibility of making maximum profit for the company. By using these methods in their service, it can help the company to measure the profit, a benefit in the business point of view. When the company has maximum profit, they can expand their business in another place. Hence, the image level of the company will be increased.

2. Transportation Model

Hamdy A. Taha (2002) said that "the transportation model is a special class of linear programming that deals with shipping a commodity from sources (factories) to the destination (warehouse). The objective of transportation model is to determine the shipping schedule that minimizes the total shipping cost while satisfying supply and demand limits. The number of units shipped on a given route will be assumed to take on the shipping cost is proportional. In general, the transportation model can be extended to other area works of operation that included the inventory control, employment scheduling and the personal assignments". When the operation of the ship has problems or while the shipping is in docking, the worker can do other works to avoid the delay in the operation. The ship operation will operate without any delay, and it can minimize the cost.

The origin of the transportation problems that was presented by Hitchcock (1941) was the first significant contribution to the solution the transportation problem. The transportation problem is namely like that because its application that have involved in the determining the transport goods. Then, the transportation model can be solved with the regular linear programming. It is because the linear programming has the unique structure will allow development a simplex – based computational algorithm to use primal – dual relationship.

The company will have more than one destination to supply the resources based on the customer demands. Thus, they must supply all resources to the client based on the destinations. It will oblique more cost if the destinations are a long distance from each other, and these models will be minimized the operation cost. Cakmak & Erosz (2007) stated that the transportation cost will be minimized if total resources supply and customer demand are equal, and the formulation is called balanced.

Pushpa & Murthy (2014) claimed that the transportation problem has become a standard application of industrial organizations that involved manufacturing units, warehouse and distribution channel. It shows the transportation problems always occurred in the industry even though they use

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numerous methods to solve these issues.

Salami (2014) stated the transportation problem is a particular type of linear programming problem that involves the following steps:

1. Finding an initial feasible solution
2. Testing the solution for optimally
3. Improves the solution when it is not optimal
4. Repeating the steps (ii) and (iii) until the optimal solution is obtained.

With these steps, the manager will apply these models to the operation in a way to ensure the operation are smooth, profit will be increased, and cost will be decreased at the same time. Transportation model only be applied after several assumptions have been made.

3. Least Cost Method

The least cost method is one of the method for obtaining initial basic feasible solution for transportation problems in operations, where more than one supply centres and demand centre are there and the aim to achieve the least cost of the transportation (Business concept, 2011). The least cost method is very useful because it reduces the computation and the time required to determine the optimal solution. This method also takes less time to solve the problem.

From Taghrid et al (2009), the concepts of the least – cost method is finding a better-starting solution by concentrating on the cheapest routes. The method starts by assigning as much as possible to the cell with the smallest unit cost. The satisfied row or column is crossed out, and the amount of supply and demand is adjusted accordingly. If both of row and column are satisfied simultaneously, only one is crossed out. This method allocates as much as possible to the least – cost cell. Ties may be broken arbitrarily. The row and column that have been completely allocated are not considered, and the process of allocation is continued. The procedure is completed when all row and column requirements are addressed. Steps in the least – cost method as follows:

i. Select the cell with the lowest transportation cost among all the rows and column of the transportation table. If the minimum cost is no unique, then select arbitrarily any cell with the lowest cost.

ii. Allocate as many units as possible to the cell determined in step 1 and eliminated that row in which either capacity or requirement is exhausted.

iii. Adjust the capacity and the requirement for the next allocations.

iv. Repeat the step 1 to 3 for the reduced table until the entire capacities are exhausted to fill the requirements at the different destinations.

4. Northwest Corner Method

From Vinay (2010), the northwest corner method is a method for computing a basic feasible solution of the transportation problem, where the basic variables are selected from the north – west

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corner (top left corner). The Northwest – Corner method, as the name implies, begin allocation by starting at the northwest corner of the matrix (Cell S1, D1 and assigning as much as possible to each cell in the first (Assign as many units as possible to each cell to meet the requirements of having no more than m + n – 1 filled cells, where m = number of rows and n= number of columns). The procedure is then repeated for the second row, third row, and so on until all rows and column requirement are met. Steps in the northwest corner method as follows:

i. Select the northwest (upper left-hand corner) of the transportation matrix and assign as many units as possible equal to the minimum between available supply and given demand.

ii. Adjust the supply constraint and demand constraint in the respective rows and columns.

iii. If the supply for the first cell is fulfilled, then we move horizontally to the next cell in the second column.

iv. If the supply for the first row is over, then we need to move down to the first cell in the next row.

v. For any cell, if the supply and demand equal, then the next allocation is made in a cell of the next row or column.

vi. The process needs to be continued until all the supply and demand are exhausted.

5. Methodology

5.1 Interview and survey

The interview method was used in the research for collecting data from the Ipoh Cargo Terminal staffs. The data collected was used to get the solution. This interview will be found out more about the transportation used in supplying the demand for the good to the destination. From the interview, the information about how many routes the train will follow and how the project manager produces a schedule to avoid delay between routes will be obtained as well. If the schedule is not well managed, it will cause more delay. The interview also significant to know about the fees rate will be charge to the customer.

This research was conducted at ICT, due to its involvement in supply and demand. Suitable interview questions was conducted to survey any related cost that involved in the shipping operation industry. From the survey, information regarding the cost that used in operations of rail, how they control employment works, route of rail and maximum profit were obtained. With these, it is possible to know about the cost of supplying the goods to the customers.

5.2 TORA Software

TORA is an algorithm or a mathematical set of instructions or programs (mathematical – software). It is an optimization system in the area of operations research which is very easy to use. Further, TORA is menu – driven and Windows – based which it makes very user-friendly. TORA stand for Temporary – Ordered Routing Algorithm. From Rajesh (2009), the TORA software has inbuilt tutorial for the notice, and it also produces animated graphical linear programming solution. The other features of the software include dynamic construction of 'Critical Path Method' chart and the creation of search – trees to name some. The software can be executed in automated or tutorial mode. The automated mode reports the final solution of the problem, usually in the standard format followed in

commercial packages while the tutorial mode keeps on giving step – wise information about the methodology and solution.

The various models in operations research which can be solved using the Temporary – Ordered Routing Algorithm (TORA) include Linear Programming Graphical, LPP: Transportation Models, Integer Programming, Queuing Models, CPM/PERT, Game Theory, Matrix Inversion, Simultaneous Linear Equation and others. The functionality tool in the 'Temporary – Ordered Routing Algorithm' features a schema browser, SQL worksheet, PL/SQL editor & debugger, storage manager, rollback segment monitor, instance manager, and SQL output viewer.

The reason TORA was chosen to be used in solving transportation problem is the program are user-friendly and also compatible with the Window 7 system. Besides TORA, there is other software that can be used such as Scilab, LINGO, and MATLAB.

6. Finding & Discussion

The findings are shown below:

Research Question 1: What the amount charge or fees and additional charge at Ipoh Cargo Terminal (ICT)?

The table below shows the rate charges of a container ship for the customer, shipping line, maritime transport agencies, freight forwarder, forwarding agent, and haulier.

Table 6.0: The rate charges of a container

State	Revised rate
Empty Container (From Northport)	RM 310/ 20' RM 515/ 40'
Empty Container (From Westport)	RM 340/20' RM 585/40'
FCL Laden Container	RM470/20' RM 715/40'
LCL/FCL Laden Container	RM 540/20' RM 800/40'

Table 6.1: One Way Laden by Road of Port Klang

One Way Laden by Road	20'ft	40'ft
Port Klang Sector (FCL)	RM1,000.00	RM 1,300.00
Port Klang Sector (LCL)	RM1,070.00	RM 1,400.00

Table 6.2: Additional charges

Additional Charge	Rate Charge

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Depot gate charge (DCG)	The rate charge of depot gate charge is from the RM 10 to RM23. It is based on the place a container bring the goods.
Overweight Surcharge: Exceed 24 tons and above (Container + Cargo weight	RM160
FCL laden container charge from the Port Klang to ICT	RM470 /20'ft RM715 /40'ft
LCL laden container charge from the ICT to Port Klang	RM540 /20'ft RM800 /40'ft

Table 6.3: LOLO charges for MT

Container	Rates charges (RM)
Per 20'ft Container	RM22.00
Per 40'ft Container	RM38.00

Table 6.4: LOLO charges for laden

Container	Rate Charges (RM)
Per 20'ft Container	RM 43.00
Per 40'ft Container	RM 73.00

Research Question 2: How much the total net cost delivery cost at Ipoh Cargo Terminal (ICT)?

Table 6.5: Total net cost delivery cost at Ipoh Cargo Terminal (ICT)

State	Area	Normal charge a container (RM)	Depot gate charge (DGC) (RM)	LOLO Charges (RM)	Total cost (RM)	Profit (10 percent of the total cost) (RM)	Net cost (RM)
Ipoh Cargo Terminal	Port Klang	2,300	RM20	116	2164	216.40	1,947.60
	West Port	925	RM16	60	849	84.90	764.10
	North Port	825	RM16	60	749	74.90	674.10
Westport	Port Klang	3,225	RM22	176	3,027	302.70	2,724.30

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	West Port						
	North Port	1,750	RM21	60	1,669	166.90	1,502.10
North Port	Port Klang	3,125	RM20	176	2,929	292.90	2,636.10
	West Port	1,750	RM22	60	1668	166.80	1501.20
	North Port						
Port Klang	Port Klang						
	West Port	3,225	RM20	176	3,047	304.70	2,742.30
	North Port	3,125	RM22	176	2,927	292.70	2,634.30

Research Question 3: What is the best transportation method in calculating the delivery cost to Ipoh Cargo Terminal by using train system?

1. By using the Vogel's Approximation Method

Table 6.6: Vogel's Approximation Method calculation

ORIGIN	Pt. KLANG	WESTPORT	NORTHPORT	SUPPLY	ROW PENALTY					
ICT	1,947.60 *(25000)*	764.10 *(25000)*	674.10 *(25000)*	75000	90	90	90	90	90	90
WESTPORT	2,724.30	*(75000)*	1,502.10	75000	1222.20	-	-	-	-	-
NORTHPORT	2636.10	1501.20	*(75000)*	75000	1134.90	1134.90	-	-	-	-
PORT KLANG	*(75000)*	2742.30	2634.30	75000	108	108	108	-	-	-
DEMAND	100000	100000	100000	300000						
COLUMN PENALTY	776.70	737.70	828							
	776.70	737.70	828							
	776.70	737.70	828							
	776.70	737.70	828							
	776.70	737.70	-							
	-	737.70	-							

Table 6.6 shows the calculation of the Vogel's Approximation Method (VAM). From the table, it shows the initial feasible solution that Vogel's Approximation Method (VAM) make for train transportation model. The Vogel's Approximation Method (VAM) shows the minimum cost from the real total cost of the transportation problem. The associated objective value for this solution is

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z = 75000 × 0 + 75000 × 0 + 75000 × 0 + 25000 × 674.10 + 25000 × 1947.60

+ 25000 × 764.10 = 85320000---------- (1)

2. By using the Least Cost Method

The D1, D2, and D3, as the retail place for the supply and S1, S2, S3, S4 is the for origin place demand.

Table 6.7: Least Cost Method calculation

		D_1	D_2	D_3	
Origin		**PK**	**WP**	**NP**	**SUPPLY**
S_1	ICT	1974.60	764.10	674.10 (75000)	~~75000~~
S_2	WP	2724.30	0(50000)	1502.10 (25000)	~~75000~~ ~~25000~~
S_3	NP	2636.10 (25000)	1501.20 (50000)	0	~~75000~~ ~~50000~~
S_4	PK	0(75000)	2742.30	2634.30	~~75000~~
DEMAND		~~100000~~ ~~75000~~	~~100000~~ ~~50000~~	~~100000~~ ~~25000~~	T:300000

The number of basic variable is 4 + 3 – 1 = 6. It is based on the formula that for the initial feasible number. The total transportation cost associated with the solution calculated as given below:

Z= 75000 × 674.10 + 50000 × 0 + 25000 × 1502.10 + 25000 × 2636.10 + 50000 × 1501.20 + 75000 × 0
= 229072500 ---------- (2)

3. By using the Northwest – Corner Method

Table 6.8: Northwest Corner method calculation

		D_1	D_2	D_3	
Origin		**PK**	**WP**	**NP**	**SUPPLY**
S_1	ICT	1974.60 (75000)	764.10	674.10	~~75000~~
S_2	WP	2724.30 (25000)	0 (50000)	1502.10	~~75000~~ ~~50000~~

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S_3	NP	2636.10	1501.20 (50000)	0(25000)	~~75000~~ ~~25000~~
S_4	PK	0	2742.30	2634.30 (75000)	75000
DEMAND		~~100000~~ ~~25000~~	~~100000~~ ~~50000~~	~~100000~~ (75000)	T:30000 0

The total transportation cost is calculated by multiplying each Xij in an occupied cell with the corresponding cij and adding as follows:

$$Z= 75000 \times 1974.60 + 25000 \times 2724.30 + 50000 \times 0 + 50000 \times 1501.20$$

$$+ 25000 \times 0 + 75000 \times 2634.30 = 488835000 \text{ ---------- } (3)$$

8. Conclusion and Future Recommendation

The main purpose of this research is to determine the Ipoh Cargo terminal operation schedule that minimized the operation cost by using railway system. From calculation, it shows that one of the methods is most suitable to reduce the operation cost. The findings are shown that the cost of train delivery system in supplying the good from the ICT to Port Klang, West Port, and North Port can be minimized using transportation models.

Besides that, the study shows the Vogel's Approximation Method (VAM) can be minimized the cost compared to other methods. From the Vogel's Approximation Method (VAM), it produces total transportation cost of RM 85,320,000 instead of RM 229,072,500 and RM 488,835,000 from Least Cost Method and Northwest Corner method respectively. From the calculation, it shows the Vogel's Approximation Method (VAM) can be used to minimize the operation cost of the train delivery system. The result also shows Vogel's Approximation Method can minimize the total delivery cost 3.72% less than Least Cost Method and 17.45% less than The Northwest Corner method. Hence, the company will be gained more profit, and the business operation will be more efficient.

Furthermore, by using Vogel's Approximation Method (VAM), the company can be identified the opportunity to improve the system used in the management and operation. If the improvement was done, the company can expand and improve their services locally and internationally. The suitable method in their operation can help them more capable of solving any problems faced by the company. Optimization methods also can give numerous benefits by solving transportation problem with the optimal solution and efficiency.

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