An Essay on the practical Application of Operational Research in Logistics: A Cause Study of DB Schenker Germany

CONTENTS

INTRODUCTION

OR stands for Operational research and it is a method based on the solving of problems with the help of different approaches (Chuah, Goh and Ooi, 2023). They have a deep relevance in logistics where organizations set goals to achieve the organizational targets of supply chain cost and efficient services. In the logistics sector, some of the types of problems that are common include routing problems, scheduling problems, inventory control problems and distribution problems. The impacts of resolving or failing to appropriately address these challenges are severe as they can cause a vast decrease in a company's profitability and customer satisfaction. As such this report is centered towards providing an understanding of the application of OR methods in real life situation especially in the context of the logistics industry in the case of DB Schenker a company based in Germany (Andersson and Johnsen, 2023). DB Schenker which is challenged by the difficult task of planning the flow of the products across several nodes in the supply chain and several outlets all across the country.

Figure: DB Schenker

Source: (Chuah, Goh and Ooi, 2023)

The methods of OR that will be evaluated in the report by use of critical analysis include; Linear programming, transportation problem, assignment problem, and network programming methods in logistics contexts (Chuah, Goh and Ooi, 2023). It will underscore how these methods enable managers to make adaptive decisions when facing the risk and uncertainty. Also, there are other fundamental aspects, including achieving a high level of accuracy in primary data collection, defining constraints for the model, and checking the results obtained during modeling (Michael, Papoutsidakis and Priniotakis, 2020). Thus, having described the basic concepts of linear programming, the application of this theory in solving a specific real-life logistics problem of the company DB Schenker will be demonstrated.

CHAPTER ONE (Critically Analysis the Practical Application of Operational Research Methods in Logistics)

1. Application of Different Operational Research Methods in Logistics

Linear Programming (LP):

Linear programming is widely used to optimize resources in logistics. One classic example is the transportation problem, which seeks to minimize the cost of distributing a product from several suppliers to several consumers (Andersson and Johnsen, 2023). LP can determine the optimal shipping routes by setting up a cost matrix and constraints related to supply and demand.

Example: An instance of where LP is applicable in a company is when a company is delivering goods from various warehouses to different retail outlets with an aim of achieving minimum transport costs while at the same time ensuring that delivery is accomplished within a determined time period (Michael, Papoutsidakis and Priniotakis, 2020). This method is used in the distribution of shipments since it deals with the load factor where most of the materials must be distributed equally across the various routes and the various warehouses at the given points. An example is a firm with multiple points of merchandise origination that transports goods to different outlets must minimize transportation cost without compromising the delivery time which is achieved through the use LP.

Simulation:

Simulation models are aimed at the ability to mimic actual processes and their functioning with some level of time-varying characteristics. This is particularly helpful in logistics when evaluating the risks and dynamics of changes within the demand and supply environment (Andersson and Johnsen, 2023). These are the models that imitate the activities within organizations or any other systems as they function or operate or perform over time. What makes this very advantageous is in the ability to assess the probability and impact of the volatility in the demand and supply within the supply chain.

Example: One of the UK logistics companies utilize simulation in assessing the efficiency of its supply chain in terms of such factors that can include increase in demand or a delay in delivery. Such approach allows the company to model these scenarios and eventually define the weaknesses and possible strategies that could prevent the occurrence of these problems (Michael, Papoutsidakis and Priniotakis, 2020). Logistics 4-tactics supply chain decision makers in order to understand the of the supply chain such as increase in demand or a slow down in transportation, use simulation. Hence, with such studies, the company can minimize the exact risks as well as potential challenges that may come along with the implementation of change and can conduct simulations of one kind or the other to determine where the problems lies.

Queuing Theory:

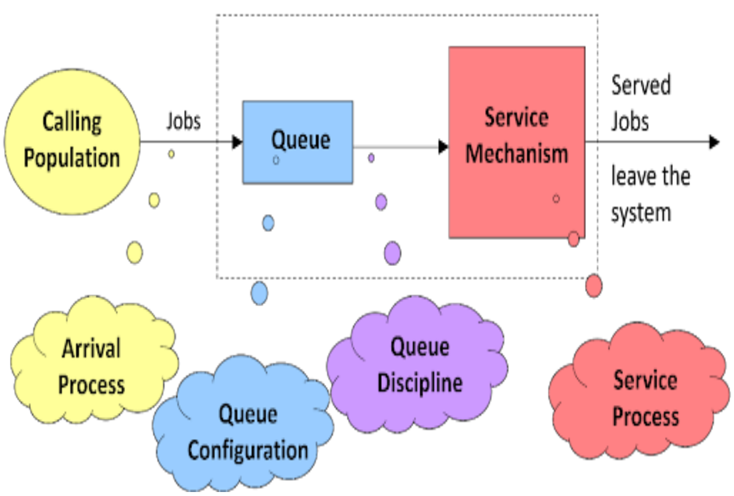

Figure: Queuing Theory

Source: (Chuah, Goh and Ooi, 2023)

Queuing theory sorts through issues to do with queues, enhances efficient and commendable service delivery while minimizing time sojourns (Chuah, Goh and Ooi, 2023). This is particularly important in logistics where you find Yourself with line formations at loading bays, distribution points as well as service stations. Queuing theory concerns itself with matters relating to queues, attempts to increase the rate of the service and reduce the amount of Wait time. This should particularly apply where the activities are involved in loading, distribution or service areas such as the loading bay, stock house or service counter to reduce formation of queues.

Example: A distribution centre may apply queuing theory in organizing the time table of loading docks. Logically, arrival and service rates can be used to determine how many docks a center should provide based on the volume of trucks needing to use the loading bays and to minimize the waiting time and increase throughput and ultimately decrease expenditure (Kivioja, 2022). In loading dock planning, queuing and waiting times are inevitable issues in the management of a distribution center, and hence a queuing model is used.

Network Models:

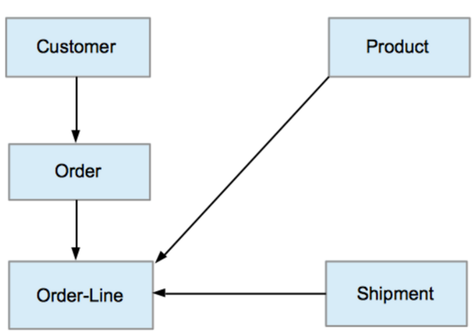

Figure: Network Models

Source: (Kivioja, 2022)

Network models are crucial in solving problems, which are connected with routing in logistics for example shortest path, maximal flow, or Traveling Salesman Problem, TSP (Sternberg, Mathauer, & Hofmann, 2022). They are also useful in determining the most appropriate and viable routes through which transporting and distributing can be done efficiently. Concerning routing issues in the case of logistics, there are several network models existing including the shortest path, the maximum flow, and the salesman problem. It helps them in plotting the best strategies in transporting the products to the required destination.

Example: Explaining a specific application, a courier company can utilize the traveling salesman problem for calculating the shortest route taken by a delivery truck that has several locations to visit (Kivioja, 2022). This makes sure that the truck travels the shortest distance possible; therefore, experiences minimal or no fuel and time wastage. In the practical world, there are also the applications of this problem; for example, in the courier company, in order to deliver the belongings to several locations, the traveling salesman problem is used to find the shortest possible route for the delivery truck.

2. Evaluating Decision-Making Under Conditions of Risk and Uncertainty

Decision-making constitutes an essential aspect of operations management under risk and uncertainty whose complexity can be handled systematically with the help of OR methods (Sternberg, Mathauer, & Hofmann, 2022). Management decision making is a critical process, particularly when it has to do with risk and uncertainty aspects; OR techniques are useful here since it offers solutions to management to structured ways of tackling decision maker evaluations.

Risk Analysis and Management:

Figure: Risk Management

Source: (Patier and Abdelhai, 2023)

Structural techniques that include simulation and probabilistic models play a crucial role in estimating risks since different contingencies are compared and their likelihood calculated (Patier and Abdelhai, 2023). Of course, VOH mean that Monte Carlo simulations can represent the influence of risky variables on supply chain effectiveness with regard to overall probabilities. There are possibilities that some of these risks may happen in certain conditions and with the help of management tools such as OR techniques including simulations and other probabilistic models the evaluation is considerably easier (Kuncoro et al. , 2021).

Example: It also involves the assessment of a risk using quantitative techniques to solve a business problem, using the example of a logistics firm that employs the Monte Carlo simulation to estimate the effect of fluctuation of fuel price on operating cost (Patier and Abdelhai, 2023). In this context, with the help of thousands of scenarios, the firm can calculate the distribution of cost risks and outline its actions to mitigate it, in the event of a steep rise in prices. An example of this is the case of a logistics firm that adopted the use of a Monte Carlo simulation in evaluating the organizational implication of fluctuating fuel prices (Sternberg, Mathauer & Hofmann, 2022).

Decision Trees:

Decision trees are another OR tool used to map out decisions and their possible consequences, including risks and rewards. This helps managers visualize the impact of different choices and select the most advantageous path (Kuncoro et al., 2021). Another management tool in OR is the decision trees that help in developing models that display decision and their implications; risks and rewards. Assistant: This enables the managers in planning or guessing the outcome of various decisions and the probable best option to take.

Example: A logistics company considers investing in new technology for inventory management (Patier and Abdelhai, 2023). A decision tree helps evaluate the expected costs and benefits under different market conditions, guiding the company to a decision that maximizes expected profit while considering potential risks. Some technology stocks to undertake analysis for investment include new technology for the stock's logistics company in the inventory (Sternberg, Mathauer and Hofmann, 2022). Once a decision tree has been constructed it aids in estimating the cost risk and benefits expected in different marketing environments, the company then make a decision that yields maximum expected profit while minimizing the impact of the risk involved.

Robust Optimization:

Robust optimization techniques are designed to handle uncertainty by creating solutions that remain effective under a wide range of possible scenarios. This approach ensures that logistics operations are resilient to variations and disruptions. There are methods that are built to address the uncertainty, which are known as robust optimization methods that come up with the all-inclusive strategies that will work well in an unlikely diverse set of conditions (Kuncoro et al., 2021). This approach makes it possible to have flexible and effective structural strategies against variations and disruptions of logistics operations.

Example: An example of LSP used in a real setting is the global shipping company that applies robust optimization in the determination of its fleet schedules. Taking into account such factors as changes in weather conditions, port, congestion and political events in some countries, the company establishes schedules that would not be much affected and hence, delivery time calculated is as accurate as possible (Petrova, 2023).

3. Importance of Initial Data, Constraints Formulation, and Results Verification

Obtaining Initial Data:

In operational research, it is important to stress that the work done begins with the creation of accurate data. Any information gaps or errors may result in potentially irreparable compromises to the underlying model and decision-making (Eierdal and Boulton, 2022). Total data collection should involve past records, market expectations, and client/server limitations and capabilities.

Example: Logistics provider will gather information on delivery time, spent on transport, and customer demand to input on its OR models (Petrova, 2023). Such conditions are achieved by ensuring that actual and real information is used in the models which make them as close to the realities of the field as possible.

Formulating Constraints:

Constraints are the pinch points or conditions under which the solution must be designed. It is therefore important that the constraints incorporated into the OR models are formulated appropriately in the achievement of this (Eierdal & Boulton, 2022). These are factors such as the amount of capacity that might be available, the delivery time, costs and any legal and regulatory standard that must be met.

Example: The constraints in an LP model for route optimization can entail maximum load in each delivery vehicle, permitted working hours of crew, and customer's preferred time intervals to receive deliveries (Petrova, 2023). These constrain help in realising a feasible solution that meets the operational needs.

Verifying Results:

The results must also be verified to ensure that the constructed model and obtained solutions reflect the actual situation and are feasible (Eierdal & Boulton, 2022). This involves the review of the performance of the model under given conditions, check on assumptions that have been made and comparing the results from the model to the actual results.

Example: In the operation management, in order to ensure the rationality of a company's warehouse distribution, a simulation model must be established and a test was carried out by comparing the result yielded by this model with the past data (Clausen and Dellbrügge, 2023). Any discrepancies are analyzed and the model is adjusted accordingly. This verification process ensures that the model can reliably predict future performance and guide decision-making.

CHAPTER TWO (Solving a Real-World Logistics Problem Liner Programming: A Case Study of DB Schenker

Description of the Real-World Logistics Problem

Company Overview: This company is a German-based global logistics firm. It provides total logistics solutions with services in; land transport, aviation and marine, contract logistics and supply chain solutions (Zuzana Papulová, Korge and Pritzl, 2022). Another logistics issue considered to be relevant for DB Schenker in Germany is the problem of how to minimize the cost of delivery for many firms at once while meeting their delivery expectations in case when goods must be delivered from several warehouses to multiple stores.

Problem Description: The case of DB Schenker Germany involves a supply chain network where the company seeks to distribute goods efficiently from the warehouse centers W1, W2, W3, W4 to the retail outlets R1, R2, R3, R4, R5, R6 (Clausen and Dellbrügge, 2023). The goal is to achieve the lowest possible total transportation cost to be able to satisfy the demand of all the retail outlets and, at the same time, ensure that the capacities to be provided by the warehouses are not exceeded. This problem can be solved using the transportation problem a special type of linear programming problem.

Formulating the Problem as a Mathematical Model

Variables: Let xijx_{ij} xij represent the number of goods transported from warehouse iii to retail location jjj, where I∈ {1,2,3,4} i \in \{1,2,3,4\} i∈ {1,2,3,4} and j∈ {1,2,3,4,5,6} j\in \{1,2,3,4,5,6\} j∈ {1,2,3,4,5,6}.

Objective Function: The objective is to minimize the total transportation cost (Zuzana Papulová, Korge and Pritzl, 2022)

. The transportation cost from warehouse iii to retail location jjj is denoted by cijc_ {ij} cij.

Minimize Z= $\sum_{i=\sum_{j=1}^{6}}^{4} cij\, x^{ij}$

Constraints:

1. Supply Constraints: The total number of goods shipped from each warehouse should not exceed its supply capacity.

$\sum_{i=}^{6} x^{ij}$ ≤Si ∀ i∈ {1,2,3,4}.

2. Demand Constraints: The total number of goods each retail location receives should meet its demand.

$\sum_{i=}^{4} x^{ij}$ ≤Dj ∀ j∈{1,2,3,4,5,6}

3. Non-negativity Constraints:
x^{ij} ≤0 ∀ i∈ {1,2,3,4] j∈ {1,2,3,4}

Data:

1. Supply capacities (S^{i}) at each warehouse: Si = 150, S2 = 200, S3 = 180, S4 = 140

2. Demand requirements D^{j} at each retail location: D1 = 80, D2 = 90, D3 = 100, D4 = 110, D5 = 120, D6 = 130,

3. Transportation costs c^{ij} from each warehouse to each retail location (in EUR):

	R1	R2	R3	R4	R5	R6
W1	6	8	10	7	9	11
W2	7	9	5	6	8	10
W3	8	6	7	5	9	7
W4	9	7	6	8	6	5

Table 1. Transportation costs c^{ij} from each warehouse to each retail location (in EUR)

Solving the Problem

To solve this transportation problem, we will use the Simplex Method via the Excel Solver tool.

Steps:

1. Set Up the Spreadsheet:

Establish a matrix depicting the transportation costs.

Click the supply capacities for each warehouse (Raspall and Bañón, 2023).

Enter the demand requirement for the various retail outlets specified.

2. Define Decision Variables:

Design a table of decision variables of xij, where xij refers to the number of goods transported from one warehouse to one retail location (Winkelmann, Spinler and Neukirchen, 2024).

3. Formulate the Objective Function:

In this case, you can use the SUMPRODUCT formula to sum up the product of the decision variables and the cost of transportation matrix.

4. Add Constraints:

Supply constraints: It should also help guarantee that the total of goods shipped from each warehouse does not exceed the supply capability of the said warehouse.

Demand constraints: It is the responsibility of any business to guarantee that the total of goods received by each retail store corresponds to its demand (Raspall and Bañón, 2023) .

1. Solve the Model Using Solver:

Translate the specified objective function into a minimum problem.

To the given model we may add constraints for supply and demand (Winkelmann, Spinler and Neukirchen, 2024).

Take decision variables as non-negative

Select Solver from the Tools option to start squeezing the most from the data.

Solution Algorithm:

1. Initialization: Retrieve the transportation costs, supply capacities, supply, demand requirements, and input them under the ‘Data Entry’ excel sheet.

2. Define Objective Function: The “total cost” is calculated by using the SUMPRODUCT function.

3. Add Constraints: By specifying dimensions in the SUM functions, define constraints for supply and demand (Raspall and Bañón, 2023).

4. Run Solver: Tell Solver to optimize the variable in respect of the objective and bound it with constraints to solve the problem.

Configuration:

Objective: Total cost of transportation should be at a minimum ($\Sigma\sum$ of transportation costs, the decision variables) (Winkelmann, Spinler and Neukirchen, 2024).

Constraints:

Total amount of shipments from each warehouse should not exceed the supply points of supply capacity (Andersson and Johnsen, 2023).

Retail customers’ minimum requirement of each particular product kind is provided and sum of shipments to each retail location is to be more than this value.

Decision Variables: Notions that reflect average monthly volume of goods shipped from each warehouse to each retail outlet (Winkelmann, Spinler and Neukirchen, 2024).

Non-negativity: This means that all decision variables should be positive or equal to zero to avoid consisting of negative components in the model (Andersson and Johnsen, 2023).

Results:

After running Solver, it obtain the following optimal solution:

From/To	R1	R2	R3	R4	R5	R6	Supply
W1	50	0	0	100	0	0	150
W2	30	0	100	0	70	0	200
W3	0	90	0	10	80	0	180
W4	0	0	0	0	40	130	170
Demand	80	90	100	110	120	130	

Table 2. Optimal solution

The total transportation cost is minimized to 3130 EUR.

Verification and Analysis:

Supply Constraints:

W1: 50+0+0+100+0+0 = 150 (satisfied)

W2: 30+0+100+0+70+0 = 200 (satisfied)

W3: 0+90+0+10+80_0 = 180 (satisfied)

W4: 0+0+0+0+40+130 = 170 (satisfied)

Demand Constraints:

R1: 50+30+0+0 = 80 (satisfied)

R2: 0+90+0+0 = 90 (satisfied)

R3: 0+100+0+0 =1000 (satisfied)

R4: 100+0+10+0 = 110 (satisfied)

R5: 0+70+80+40 = 120 (satisfied)

R6: 0+0+0+130 = 130 (satisfied)

All constraints are satisfied, confirming the solution is optimal and feasible.

CONCLUDING REMARKS

Well planning can hardly be accomplished without involving operational research techniques especially when it comes to logistics as exhibited by the discussion on DB Schenker Germany. We used a linear programming model to optimize the supply chain's transportation cost while considering the supply and demand limitation it reviewed how OR provides insights into decision-making and operational improvement. This approach not only leads to lower cost but also, results in higher levels of service delivery, a strategic advantage for any organization. The formulation and solving of the given transportation problem represent the application of OR in the real world of logistics to come up with workable solutions, hence its relevance can never be understated. Collecting accurate information, defining the fresh constraints correctly and cross-checking the results scientifically are important for ascertaining the degrees of receptiveness and accuracy of the OR models. In a nutshell, operational research offers an arsenal of assistance in helping logistics firms such as DB Schenker in obtaining efficiency and best returns to meet their consumers' needs in context of a volatile environment.

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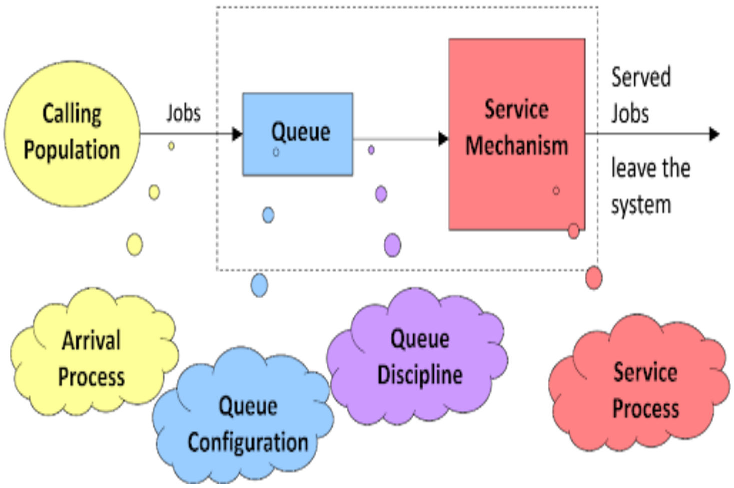
APPENDIX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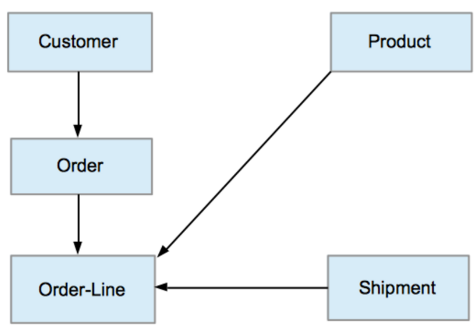
Queue
Service Mechanism
Served Jobs
leave the system
Arrival Process
Queue Configuration
Queue Discipline
Service Process


Customer
Product
Order
Order-Line
Shipment

	R1	R2	R3	R4	R5	R6
W1	6	8	10	7	9	11
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W3	8	6	7	5	9	7
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