Minimization of Trucker Idle Time and Transportation Cost in Container Delivery

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Abstract— For any manufacturing company, they need to ship their products to other companies or their consumers. In some cases, companies use third-party logistic (3PL) companies to transport their product. This can help companies get their product to where they need to go within a given time frame. This project focused on a furniture company that outsources to a logistics company to ship their products to customers. The trucking company has containers to transport any product. The furniture company does not have the resources they need to deliver their product to their customers. Thus, the trucking company takes the furniture products and deliver them to the respective customers. Currently, a trucker will deliver the product to the customer and waits until the customer unloads the product out of the shipping container. There can be extended periods of time the trucker will have to wait. The longer the wait times, the slower it is for the furniture products to arrive at the customer locations. To limit the idle time and transportation cost, this project aims to analyze and determine if a new policy can decrease the idle times and transportation cost.

Keywords- Optimization, Python, Transportation cost, Idle time

I. INTRODUCTION

A furniture company needed to deliver full containers, with furniture, to their customer locations. However, the furniture company did not have the necessary resources to carry out their own deliveries. Consequently, they outsourced to a third-party logistics company that will provide the furniture company with trucks, truckers, and containers to fulfill their demand. In the current policy, the truckers are assigned a number of containers to deliver to different customers. In each delivery, the trucker must wait for the container to be fully emptied by the customer at the customer site before taking the empty container back to the depot. Then the furniture company loads the containers with product for future deliveries. However, a major issue is the amount of time it took for customers to unload their containers. It varied and could take longer than an hour just to unload a container. Therefore, truckers waiting for this to be done was non-value added time where the trucker literally waited. The team investigated and came up with a new policy to help minimize the wait time and utilize the truckers more efficiently.

II. PROJECT DESCRIPTION AND SCOPE

In this project, the team focused on developing a new transportation policy for the trucking company. The main concerns included the amount of time it took the truckers to transport a container from the depot to the customer location and back. In addition, the team focused on minimizing the amount of time the trucker waits for the customer to unload the truck. The project does not include the way the product is package nor the way it is loaded in the container. Finally, the composition of the merchandise stored in the container was not in the scope of the project. The scope of the project included only changes in transportation policy related to the transportation time and idle time, and the number of rental containers required.

III. PROJECT OBJECTIVES

A. The Idle Time

There are two objectives that project focused on. Since the idle time is an important component in the project, the team will focus on minimizing the total idle time of the trucker at each customer location. This will let the team show how much time truckers spent executing the current policy versus the proposed policy.

B. The Cost of Transportation

The second objective was to minimize the cost of transporting full and empty containers. The logistics company is the company that delivers the product within the containers. The containers are a critical resource for logistics company and the furniture company. The truckers took the container from the depot to the respective furniture customer and returned it once the task is finished. The more time truckers wait for the customer to finish unloading, the more delay time existed and potentially cost would increase. In order to minimize the idle time, the cost needs to be minimized as well.

IV. CURRENT STATE

The current state was modeled as an integer linear programming optimization model. The objective function was to minimize the number of rental containers required, the total transportation cost and the total number of truckers needed. The constraints were to (1) ensure the truckers did not work more than their available time, (2) meet demand and allow for early delivery of containers, and (3) nonnegativity constraints.

V. PROPOSED POLICY

The proposed policy was designed to address the high wait time in the current policy. The proposed policy allowed the trucker to drop the container off at the customer location and then leave to make other deliveries and pickups. Therefore, the wait time of the trucker in the system is removed. Since containers were dropped off, truckers must return to pick them up on another day. This also introduced situations where the trucker would drive with no container attached. As a result, the total rental cost of the containers
will increase, since the truckers will handle more containers and containers are being left at the customer locations for them to unload in their own time. The proposed state is an integer programming problem, similar to the current state. The optimization model was solved using Python and IBM ILOG CPLEX solver with the packages docplex, cplex, pandas, openpyxl, and numpy packages.

A. Equations

Eq. 1 was the objective function, stating to minimize the transportation cost of full containers, empty containers and no containers, and the number of truckers needed. Eq. 2 limited the number of hours a trucker can work. Eq. 3 ensured truckers left and returned to the depot. Eq. 4 was a flow balance constraint for containers at all locations. Eq 5-7 made sure demand was satisfied and allowed for early demand delivery. Eq. 8 stated that dropped off containers are ready for pickup the next day, and eq 9-10 were the number of containers left at any location that must be emptied by the next day.

\[
\text{Minimize } \sum_{t \in T} \sum_{v \in V} \sum_{i \in L} \sum_{j \in L} \left( c^F (w_{ij} + x_{ij}) + c^E S_{ij} x_{ij} + c^N S_{ij} y_{ij} \right) + \sum_{v \in V} \sum_{t \in T} z_{vt}
\]

Subject to

\[
\sum_{i \in L} \sum_{j \in L} r_{ij} (w_{ij} + x_{ij} + y_{ij}) \leq K^M z_{vt}, \forall t \in T, \forall v \in V
\]

\[
\sum_{i \in L} \sum_{j \in L} r_{ij} x_{ij} + y_{vt} = \sum_{i \in L} w_{0i} x_{0i} + y_{0j}, \forall t \in T
\]

\[
\sum_{v \in V} \sum_{i \in L} y_{ij} + w_{0i} = \sum_{v \in V} x_{0v} + \sum_{i \in L} y_{ij} + I_{it}, \forall i \in L, t \in T
\]

\[
\sum_{v \in V} w_{vit} \geq f_{it}, \forall i \in L, t \in T
\]

\[
f_{it} = d_{it}, \forall i \in L, t \in T
\]

\[
f_{it} = f_{i(t-1)} + d_{it} - \sum_{v \in V} w_{v,i,t-1}, \forall i \in L, t \in T
\]

\[
\sum_{v \in V} x_{v,i,t} \geq I_{i,t-1}, \forall i \in L
\]

\[
I_{it} = \sum_{v \in V} x_{v,i,t} - w_{v0,t}, \forall i \in L
\]

VI. RESULTS AND CONCLUSIONS

The optimization program was set up to perform 20 different random instances of a scenario. 4 scenarios were created for testing. The “Near” scenarios were where the network of customer locations was nearby the depot. It was tested with 5 locations and 10 locations. The same was done for a “Far” scenario, where the network created customer location located further away. The parameters of the problem (i.e. cost to transport a full container, rental cost) were arbitrarily determined. The rental cost, travel cost, and total truckers were compared between the current state and proposed state. The first cost associated with the system is the rental cost, which was higher in every situation of the proposed policy. This is an obvious difference since the truckers can now drop the container off, which allows for the truckers to handle other deliveries and drop-offs. This also increased the logistics company’s ability to move more containers since truckers weren’t idle and waiting for a container to be unloaded. The total transport cost of the proposed state is 1.5% to 4% lower in all scenarios of the proposed policy. The number of truckers used in the system was reduced by 28% to 60% in the proposed policy.

With the reduction of truckers involved and the reduction of transport cost, the proposed policy is less costly than the current state to ship the containers to the customers. Furthermore, the proposed policy is more time-efficient than the current state, which means more containers can be shipped per day, which increases the revenue of the logistics company. The Logistics company is paid per container delivered therefore an increase in delivery rate is a direct increase to revenue.

![Figure 1. Average Total Transportation Cost](image1)

![Figure 2. Average Total Truckers](image2)

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