Fowler Distributing Company – Logistics Network Routing Analysis

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Executive Summary

Our firm was contracted by Fowler Distributing Company to provide analysis of the company's current and potential vehicle routing in an effort to optimize the distribution network of beer and wine products from a central warehouse to 21 clients. Using the current route and costs as a baseline, we provide counsel regarding the efficacy of the current network, and propose several alternative scenarios through which savings in mileage, labor and time costs can be achieved. Where the potential for savings is insignificant or non-existent, we provide detailed explanation of the profit-loss scenario using break-even analysis.

The company currently has five delivery vehicles of 500 case capacity. These vehicles service all 21 pre-sell accounts at a fuel cost of $1.20/mile. The trucks are currently 3 years old, and can be sold after their 7-year useful life for $2,000. The current delivery drivers are paid $13/hour, which includes fringe benefits. Overtime costs are at double the standard rate of pay for shifts that exceed 8 hours, and mandatory thirty minute lunch breaks are required between 11:30 AM and 1:30 PM. Trucks must leave the depot for daily deliveries no earlier than 6:30 AM and no later than 8:00 AM.

We begin our analysis by optimizing the current route based on least-cost delivery routes that both minimize the fuel and labor costs while meeting delivery time requirements called time windows. Utilizing the savings method in unison with time window demands, we determine that by optimizing just the cost and capacity constraints, a savings of over $27,000 annually can be achieved. We follow up by proposing the possibility of acquiring any combination of larger 800 case capacity trucks in an effort to reduce cost, factoring the higher fuel charge associated with such an option. We again use the savings method with time window constraints. Our findings indicate that no combination of 500 case capacity and 800 case capacity trucks is a better alternative. Due to the increased cost of fuel, the underutilization of larger trucks and the acquisition cost of larger trucks, such a decision would be more costly. We support this finding by evaluating the cash-flow potential of replacing current used trucks with larger new trucks. We find that new trucks would need to be acquired at a price of less than $3,145 in order to break-even, with the cost of acquisition sensitive to the cost of fuel.

We determine the significance of time windows in optimizing the route design. Through complete elimination of time windows we achieve an additional annual savings of $667. Because completely eliminating time windows may not be viable, we evaluate the impact of each time window. As less than 45% of clients have a time window requirement outside of the standard 8:00AM-5:00PM business day, we contend that relatively few of the clients with extraneous time window demands contribute the most significant impact to route optimization. We rank-order the clients with the most significant time window constraints and determine the recommended incentive to clients to gain more efficient routes. However, due to the minor savings achieved by offering such an incentive, we propose foregoing the small incentive to customers to relax time windows, in lieu of better customer service. We then conclude by offering further areas of analysis that may yield additional benefit to the Fowler Distributing Company's profit margin. These include warehouse location, the impact of fuel and labor costs, and alternative vehicle sizes.

Introduction

Fowler Distributing Company is a beer distributor with 21 pre-sell clients. The company was founded by Vietnam War veteran Roy Fowler to deliver beer and wine coolers for a major liquor distributor. Mr. Fowler owns the trucks and is responsible for the maintenance and fuel costs associated with the vehicles. Trucks are operated by union drivers at a negotiated rate that includes fringe benefits. While his business has done exceptionally well, Fowler is interested in minimizing the number of trucks needed to service the accounts and the miles driven.

On a typical day, the 21 pre-sell accounts may occur. These accounts require service 250 days a year and have a fixed demand for the quantity of cases per day. By utilizing the current fleet of 5 trucks, each with 500 case capacity, Fowler is able to meet both time window requirements and service time constraints for all 21 accounts. However, after further analysis we determine that the opportunity exists to achieve fuel and mileage cost savings by better optimization of the routes using the savings method. Subsequently, we evaluate the impact of both truck capacity as a constraint to developing larger routes by considering the acquisition of larger trucks and the associated fuel costs. Using cash flow analysis, we determine the feasibility of this alternative given the sale of used vehicles to acquire new vehicles. We then determine the impact of time-windows on the routing optimization problem by evaluating the potential savings achieved from relaxing the time window constraints.

Analysis

We begin our analysis by using Fowler's current vehicle routing as a baseline. Fowler uses 5 trucks, each with 500 case capacity, to service all 21 pre-sell accounts. The baseline cost to provide this service over a 250 day delivery year is $216,180. All time window requirements are satisfied and no vehicle exceeds its carrying capacity. The benefit of this scenario is that routes are familiar with the current slate of drivers. However, there are some minimal overtime costs at a double-rate, totaling $295 per year. This indicates that at least one route is exceeding the 8 hour regular shift time. The cause for this extended shift signals some inconsistency in the current vehicle routing scenario. Our first initiative is to reduce the duration of such a shift along with reducing the duration of any other shift, while still meeting the capacity and time window constraints.

A cursory review of the spatial design of the current vehicle routing shows several inconsistencies. One instance is that of overlapping paths within a single route as evidenced in the route servicing stops 12-15-1-14-5. The question arises, is it possible to redirect the order of service within this route, to eliminate the wasted travel mileage caused by the intersection?

Another inconsistency is the shape of routes. A good shape for an optimized route is that of a tear-drop. One example of a poor route shape is that of the route servicing the 16-17-8-19 range of clients. The route cuts back abruptly from client 17 to pick up client 8, and then returns to get client 19. This causes almost a doubling of mileage as opposed to connecting clients

17 and 19. In order to resolve this wasted mileage, one or more routes may need to be combined or individual clients may need to be aligned with other routes.

A straightforward method for determining optimized routes is the Clark-Wright savings method. The objective of the savings method is to minimize the total distance travelled by all vehicles and to indirectly minimize the number of vehicles needed to service all stops. Beginning at the warehouse, a route is created based on the net savings achieved by combining stops in order from most savings to least. The benefit of the savings method is that multiple routes can be designed consecutively and near optimally. These routes can then be combined and the savings from combining routes exceeds the next best savings from adding a stop to a current route while meeting other constraints such as capacity. By utilizing the savings method and then testing the resulting routes within the ROUTER software algorithm, we are able to troubleshoot our route designs to meet time window constraints. Using this method, we were able to reduce the annual vehicle routing cost to $188,652, yielding an annual savings of $27,527 or nearly 13 percent! In the process, we meet all time window requirements, do not exceed vehicle capacity, and maintain five routes, with no need to lay off a driver. Finally, the overtime cost of the baseline routing design has been eliminated. There exists no overlapping within any single route, and all routes attain the classic tear-drop shape indicative of optimality. Our optimized solution routes are as follows:

Route	Departure Time	Demand	Cost (per day)
0-11-20-8-9-5-0	7:45am	400	$ 154.97

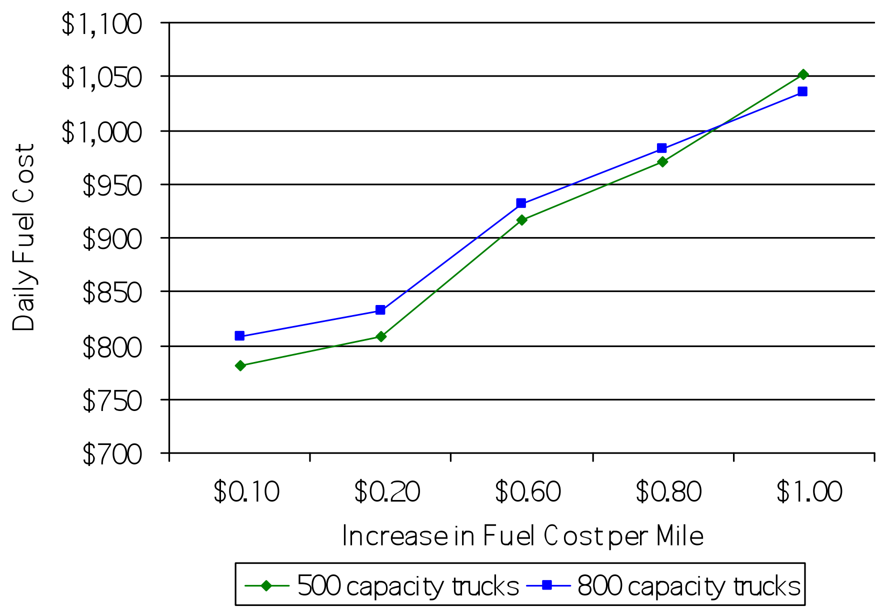
0-16-17-19-18-21-0	8:20am	460	$ 193.43
0-6-2-15-14-0	8:28am	500	$ 165.57
0-7-13-10-0	7:40am	400	$ 117.62
0-12-1-3-4-0	7:45am	480	$ 123.03
			$ 754.61 Total Cost

One scenario we explored is the option of replacing the current trucks with 800 case capacity trucks. Considering the increased fuel cost per larger truck ($1.50 per mile as opposed to $1.20) the question arises: is it feasible to expand route capacity using larger trucks and thus create savings in mileage, or perhaps even reduce the number of routes in the process? In order to pursue this option, we added larger capacity vehicles to the ROUTER software program, and applied the savings method again; this time with larger route capacities. We reduced the number of routes to four using a combination of (3) 800 case capacity trucks and (1) 500 case capacity truck. However, the annual cost for implementing these routes increased to $195,793, an increase over our previous optimal solution of $7,140 per year. While this is an improvement over the current vehicle routing design implemented by Fowler, it is over $20,000 more expensive than our optimal solution.

In addition, in order to take advantage of the reduction in number of routes, larger trucks need to be acquired. Because Fowler currently has (5) 500 case capacity trucks and would only need to use one of these, the other four trucks could be sold in order to acquire the (3) 800 case capacity trucks required to reduce the number of routes. Assuming each 500 case capacity truck can be sold for $10,000, and considering the annual loss in savings of $7,140 compared to our optimal route design, Fowler would need to find an exceptional deal on new larger capacity trucks. Each larger truck would need to be purchased for less than $3,523 in order to break even after 4 years. Considering that a new 500 case capacity truck costs $20,000, we anticipate the cost of a larger truck to be significantly more than $3,523. Therefore, we determine that such a strategy to reduce the number of routes is not feasible. Below is a cash flow analysis used in our break even analysis. An annual increase in costs of 2 percent per year was factored in this analysis.

Cash Flow Analysis					
	Year 1	Year 2	Year 3	Year 4	Total
Sell four 500 capacity trucks	40,000	-	-	-	40,000
Buy three 800 capacity trucks	(10,568)	-	-	-	(10,568)
Annual Route Costs using three 800 capacity trucks and one 500 capacity truck	(195,793)	(199,709)	(203,703)	(207,777)	(806,982)
Total Cash Outflows	(166,361)	(199,709)	(203,703)	(207,777)	(777,550)
Cash Outflows using five 500 capacity trucks	(188,652)	(192,425)	(196,274)	(200,199)	(777,550)
Difference between 2 alternatives	22,291	(7,284)	(7,429)	(7,578)	-

A key factor that causes the use of larger trucks to be infeasible is 25% increase in fuel costs associated with larger trucks. The potential to use larger trucks is cost-prohibitive so long as fuel costs remain at current levels. However, if the cost of fuel increases by $0.80 to $1.00 per mile for all vehicles, the use of larger trucks becomes more cost-effective. This is due to the increased savings per mile created by using fewer routes. However, unless there is a significant increase in fuel costs, the use of 500 case capacity trucks in a five-route design yields substantially more savings. Below is a graph depicting the relationship between the daily fuel cost and the increase in the cost of fuel per mile. You can see the point at which the 800 case capacity trucks become more cost-effective is just over an $0.80 per mile increase in fuel costs.



One area of concern is the impact of time windows on route design. While 57% of clients accept deliveries between 8:00AM-5:00PM, the remaining clients have narrower delivery time requirements. These include four stops that must be serviced in the morning. Two of these stops must be serviced before 9:00 AM. These special requirements add significant complexity in route design where the time windows prohibit clients that are geographically close to each other to share a common route (as is the case with clients 12 and 7). Other stops with time windows that are less constrained have little to no impact on the development of optimal routes (as is the case with clients 14 and 15). To determine what time windows are costing, we eliminated all time-windows from our savings method approach and recalculated the optimal route design. We determined that two routes remain unchanged, whereas time windows affect three of the five optimal routes. The three affected routes can be further optimized by removing time windows to yield an additional annual savings of $667 over our optimal five-route solution. The savings occurs by moving one stop on each route to an adjacent route, and marginally reducing the cumulative route distance as well as creating savings in labor costs by utilizing shorter routes.

Only a handful of stops with time windows contribute to the increase of route costs. In order to determine the clients with the most impact on route cost, we considered those stops where moving or re-ordering the sequence of delivery along routes affected by time windows created the most financial implication. In rank-order of significance of financial impact, we determine that stops 12 and 7 (the stops where deliveries must be completed before 8:45AM) both share the highest financial impact, followed by stop 13, and then stop 10. All four stops fall within two routes. Three of the four stops exist on the same route in our optimal solution. By relaxing the time windows, we are able to combine all four stops into one route and eliminate the conflict between stops 12 and 7 as they no longer require immediate morning service.

The savings created by combining the stops most-impacted by time-windows raises the question: what might Fowler offer as an incentive to these clients in order to optimize route design? Because both stops 12 and 7 share the equal impact of relaxing time-windows, the annual savings of $667 should be shared between the two stops as well. We proposed that if such an incentive were considered, each client could be offered a $300 yearly rebate in order to relax their time windows. Stop 12 would be requested to change delivery times from 8:00-8:30AM to 1:00-2:00PM and Stop 7 would be required to change delivery time from 8:00-8:30AM to 11:00AM-12:30PM. However, if Stop 7 was not interested in changing its time-window, we would still have a second option to offer an incentive to both Stop 12 and Stop 10. Stop 12 would change its delivery time from 8:00-8:30AM to 6:45-8:00AM (slightly earlier) whereas Stop 10 would change its delivery time from 8:00-10:45AM to 10:45AM-12:30PM. Both stops would also receive a $300 annual rebate for compliance with this request.

It is our recommendation, however, that the added savings realized by offering such an incentive is only $67 to Fowler, and therefore such an incentive should not be offered. It may be difficult to get customers to agree to the changes in time windows. The additional tension that may occur between Fowler and its clients, combined with the negligible incentive (only $1.20 per day on average for stops that relax the time windows) does not make such an incentive attractive. Therefore, we propose adhering to our optimized route design with time-windows included, as opposed to making a special consideration for relaxing the time-windows.

While we focus on the key factors of route distance and time windows, other key issues may affect the optimization of Fowler's routing design. One such factor is the location of the distributor's warehouse. Because the warehouse is not centrally located to serve all 21 stops, additional delivery time and fuel costs are associated with the added distance to service the farthest stops. By positioning the warehouse at the center of gravity of all 21 stops, the cumulative time and distance for deliveries may be reduced. Another factor is the labor contract with the union. It may be possible to negotiate the terms of hourly wages, fringe benefits and the overtime rate to reduce the cost of labor. Certainly if the requisite break-time requirement of one-half hour between 11:30AM and 1:30PM can be relaxed to any time throughout a shift, this may result in better optimization of routes by better serving stops with time windows, as well as reducing overtime.

One significant factor is the cost of fuel. Since fuel costs fluctuate, the strategy to reduce the variability of fuel costs may make using larger capacity trucks more viable. Some potential strategies may include buying fuel on volume, hedging, and co-op purchasing agreements. In addition, the possibility of using smaller vehicles for routes where even 500 case capacity trucks are underutilized may result in additional savings and greater fuel efficiency.

Conclusion

Fowler Distributing Company has an opportunity to realize significant savings in the re-design of its distribution routes. Using the savings method, we determine that annual benefit exceeds $27,000 using existing resources available to the company, and factoring delivery time requirements and current distribution warehouse operations. Optimality of routes was achieved using the savings method and a preview-solve-review technique that allows our firm to provide significant reductions in mileage and labor costs. We also evaluated the potential for savings using larger-capacity vehicles. However, upon considering the acquisition cost of larger vehicles to reduce the number of routes and the sensitivity of vehicle size to fuel cost, we find that larger vehicles actually cost more than if current resources are fully utilized. We do find marginal savings that can be realized through the relaxation of time windows; yet the soft costs associated with such a transition in scheduling, and the significant effort required to provide a small incentive to select clients to relax the time-windows may require significant time and human resource investment. We expand our analysis to present other areas where further cost savings may be realized, such as negotiations for lower labor rates, fuel futures and warehouse relocation. However, it is our recommendation that the greatest savings can be achieved by implementing our route optimization design using current vehicles, labor and warehouse location.