THE FEASIBILITY OF LOWERING ENERGY COSTS THROUGH REDUCED DELIVERY FREQUENCY

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Abstract. The feasibility of reducing delivery frequency as a means of lowering energy and transportation costs is examined. Four reduced delivery situations are examined using a net present value criteria. While substantial energy savings are possible the cost of equipment necessary to accommodate these reductions outweighs the energy savings at current fuel prices. Substantial fuel price increases are required before such reductions are worthwhile. Good management requires examination of the net effect of energy savings on net revenue.

INTRODUCTION

The rising cost of energy has been felt in nearly every segment of the economy. This is particularly the case for such energy intensive sectors as transportation where motor fuel costs have risen approximately 80 percent since 1972 (Refrigerated Transporter). Increases such as these have placed a heavy strain on the physical distribution systems of many firms, and have forced them to reevaluate their operations in order to identify areas of potential cost savings.

This paper examines the feasibility of reducing the number of weekly deliveries as a means to reduce this strain on physical distribution budgets. This study was conducted in March 1977 with the assistance of a Pennsylvania dairy that operates a chain of convenience stores and restaurants. It services these outlets as well as several independent stores on a single delivery route using a tractor trailer. In order to isolate the effects of reduced deliveries, the present routing system is improved using a computer generated solution. Four reduced delivery plans are then attempted. In each plan the savings in fuel costs are compared against the costs of additional milk cooler capacity at the stores. The acceptability of a plan is determined using a net present value (NPV) criterion.

OBJECTIVES

This study has two specific objectives. First, the determination of the savings in fuel and dollars that come as the direct result of reducing the number of weekly deliveries of fluid milk to convenience stores. Second, the determination of the minimum price of diesel fuel at which reduced deliveries to these convenience stores becomes economically feasible.

PROCEDURE

The value of computer algorithms to route delivery vehicles is well documented (Hallberg and Kriebel, Salkin and Shouse). In this paper a routing algorithm is used to calculate the potential fuel and dollar savings arising from fewer deliveries of milk per week to convenience stores. The savings in the physical distribution system are weighed against the cost of additional milk coolers at the stores in order to determine net savings. The additional milk coolers are needed to accommodate the larger quantities of milk per delivery.

The delivery vehicle is routed using the Clarke and Wright Lockset Method. The algorithm begins by sending a separate vehicle to each store. It then links the stores on routes such that the distance saved by these links is maximized. The method is called Lockset because once the links are established they cannot be broken. The amount of milk required by each store is fixed and assumed equal to the average weekly demand during March 1977. Cornell University time standards for fluid milk deliveries are used to determine "at-stop" times (Aplan and Pratt). Items other than fluid milk are delivered but since all products are packed in uniform sized cases, all products are considered homogeneous for delivery purposes. The unit of measure is half cases.

The portion of the firm's delivery system examined services 20 captive (i.e., company owned) convenience stores as well as nine independent (i.e., non-company owned) stores in one county area of Pennsylvania. The algorithm is run until the fluid milk delivery system is divided into a Monday-Wednesday-Friday (MWF) and Tuesday-Thursday-Saturday (TTS) route with several stores receiving delivery five or six times a week. The cooler capacity of a given store is assumed to be the largest delivery to that store during the study period.

The delivery vehicle is a diesel tractor with a 24-foot refrigerated trailer. It returns to the processing plant approximately midway through the day to unload empty cases and to load any additional product needed for the remaining stops. The processing plant is considered fixed, and has sufficient capacity to handle all changes in the delivery frequency.

In order to properly evaluate this situation it is necessary to compare the value of fuel savings over the expected life of the new milk coolers. The fuel savings accrue each period while the cost of the new coolers is absorbed in the first period. Therefore, the appropriate method of evaluation is net present value which considers the time value of the cash flows. The analysis is conducted using a five year time horizon which is the expected life of the milk coolers. The after tax discount rate is 14 percent.[1]

Reducing Delivery Frequency

Since the purpose of this paper is not to measure the savings possible from computer generated routing, one cannot legitimately make comparisons with the current non-improved delivery system. Therefore, the current delivery system (in terms of frequency) must be improved in order to provide a benchmark situation from which legitimate normative comparisons can be made. The application of computer routing results in potential weekly savings of 53.3 miles (11.4 percent) and 11.1 gallons of diesel fuel (11.4 percent) over the present system. The savings of diesel fuel is directly proportional to the distance savings. The weekly time, distance, and fuel costs associated with this improved system are referred to as the benchmark situation. The results of all subsequent simulations are compared to the benchmark situation.

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[1] *Fortune*, May 1977, Return to Shareholder Equity in Food Manufacturing and Processing in 1976.

Table 1
Weekly Time, Distance and Fuel Use and Savings

	Weekly Totals					
	Time		Distance		Diesel Fuel	
Situation	Minutes	Percent Savings Over Benchmark	Miles	Percent Savings Over Benchmark	Gallons	Percent Savings Over Benchmark
Present system	3,400		467.8		97.5	
Benchmark	3,282		414.5		86.4	
Reduced delivery frequency						
Situation 1—captive stores only, no lag adjustment	3,121	4.9	387.6	6.5	80.8	6.5
Situation 2—all stores, no lag adjustment	2,941	10.4	344.2	17.0	71.7	17.0
Situation 3—captive stores only with lag adjustment	3,169	3.4	403.1	2.8	84.0	2.8
Situation 4—all stores with lag adjustment	2,896	11.8	316.4	23.7	65.9	23.7

Four reduced delivery situations are examined. Situation 1 deals with the simple deletion of a single weekly delivery to each company owned store. For example, if a store normally received a milk delivery on Monday-Wednesday-Friday, the Friday stop could be eliminated. In Situation 2 the deletion of a single weekly delivery is carried out for both independent and captive stores.

While Situations 1 and 2 allow measurement of the effect of reduced frequency, they are quite unrealistic since the time between deliveries can vary greatly. For example, elimination of the Friday delivery from a Monday-Wednesday-Friday route would result in a span of four days (Thursday to Sunday) in which no milk is received. In order to overcome this problem two additional reduced delivery frequency situations are developed. In Situation 3 a delivery is deleted and the spread between delivery days is equalized for only the company owned stores. For example, if a captive store receives deliveries on Monday-Wednesday-Friday, the deletion of a single delivery could now result in a reassignment of deliveries to a Monday-Thursday schedule, thus reducing the delivery lag to a maximum of three days. Situation 4 is the same as Situation 3 except this reassignment of deliveries is now applied to all stores.

The development of less frequent delivery routes requires the adoption of a series of decision rules for constructing the new routes. The following decision rules are applied: (1) the amount of product that can be delivered to a store at one time cannot exceed the largest single delivery during the study period, (2) the amount of milk to be delivered by the delivery vehicle in a single day cannot exceed the truck capacity, (3) large fluctuations in the day-to-day workload are to be avoided, (4) a given stop must be serviced if it is passed enroute to another stop in the delivery sequence, (5) the number of days between deliveries is to be equalized, (6) the Pennsylvania eight day milk freshness code is to be observed.

The routes needed to service these new delivery frequencies are generated by the computer algorithm and the differences in weekly time, distance and fuel costs are noted.

Results

The reductions in delivery frequency brought substantial savings to the firm in terms of miles travelled and fuel consumed (Table 1). The greatest savings occurred in Situations 2 and 4 where the reduced deliveries are applied to the entire delivery route. In Situation 4 a reduction of fuel cost of 23.4 percent is possible. Comparison of Situation 4 and the present system without computer generated routes, shows a fuel and distance savings of 32.4 percent. When only the company owned stores' delivery frequency is reduced, Situations 1 and 3, the savings are smaller. In these instances leaving the delivery frequency of the independent stores unchanged diminishes the amount of the savings.

In order to evaluate properly the trade offs between the savings in fuel costs and the additional cost of milk coolers it is necessary to look at more than one time period. The fuel savings accrue each period while the milk cooler costs are incurred in the first time period. For these reasons the situation is evaluated using a net present value criterion (NPV). The present value of the fuel savings are calculated using the firm's fuel cost (55¢ per gallon) over a five year planning horizon discounted at 14 percent. The cost of the smallest refrigerated cooler (4′ x 6′ x 7′) including installation is $2,300.[2] The number of additional milk coolers that need to be purchased varies between situations since coolers are purchased

[2]Cooler purchase and installation costs were supplied by Bally Case and Cooler, Inc., Bally, Pennsylvania.

[3]Cooler operating costs include the cost of electricity at four cents per kilowatt hour.

Table 2
The Present Value of Fuel Savings, Total Cooler Cost, Net Present Value, and Minimum Fuel Price Needed to Make Reduced Deliveries Feasible

Situation Number	Present Value of Fuel Savings at Current Price	−	Total Cost of Additional Milk Coolers	=	Net Present Value (NPV)	Price of Diesel Needed to Make Delivery Reduction Economically Feasible
1 Captive store only no lag adjustment	$ 550.24		$11,500		($10,949.76)	$11.49
2 All stores no lag adjustment	1,437.98		$25,300		($24,362.02)	9.68
3 Captive stores only with lag adjustment	233.19		6,900		($ 6,666.81)	16.27
4 All stores with lag adjustment	2,006.63		23,000		($20,993.37)	6.30

Discount rate = 14 percent
Time horizon = 5 years
Fuel price = 55¢ per gallon
Fuel consumption rate = 4.8 miles per gallon
Labor cost per hour with fringe benefits: $9.51 per hour

only when delivered quantities exceeded current capacity. The additional coolers required varies between three and eleven. Table 2 shows that the costs of the additional coolers even in present value terms far outweighs the fuel savings over the five year period.

In order to assess the sensitivity of the solutions the NPV calculations are adjusted to determine the minimum price of diesel fuel that would make the cooler purchases worthwhile—an NPV of zero. The lowest breakeven price for diesel fuel with the current system is the $6.30 per gallon associated with Situation 4, the highest price is the $16.27 found in Situation 3.

Conclusions

In the situations presented above, none of the reduced delivery frequency situations proved feasible at current fuel prices when additional milk coolers must be purchased. But, substantial cost savings can be realized from reducing delivery frequency if the purchase of additional coolers can be avoided. The analysis also shows that physical distribution decisions cannot be made in isolation but must be examined in light of their impact on the total net cost to the firm. It is only in this larger context that its worthiness can be properly judged.

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