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Optimal Off-line Car Sourcing Under Deregulation

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INTRODUCTION

The implementation of boxcar deregulation, in conjunction with the 1981 revision of the AAR Car Service Rules, may well herald the eventual demise of the railroad industry's long-standing regime of routine no-cost return of empty general service equipment. The Interstate Commerce Commission's highly publicized boxcar deregulation order essentially allows roads to store surplus foreign (non-owned) equipment free of car hire, charge owning roads for its return, and negotiate bilateral car hire and car service agreements (Interstate Commerce Commission, 1983). The July 1981 revision of the industry's Car Service Rules removed the restrictions then in existence on a road's ability to reload foreign general service cars (Association of American Railroads, 1981).

Thus, this nation's railroads are entering an era where, at least for boxcars, they no longer need return without compensation surplus foreign cars. In that other roads may also not continue to automatically return cars to the owning road, railroads may also need to take a more active part in assuring themselves an appropriate supply of cars for the traffic they originate.

This paper discusses an optimal procedure for an individual railroad to select and route off-line rail cars, of any ownership, to meet on-line loading needs that cannot be fully met by on-line supplies of cars. This proposed procedure would enable a road to determine its best alternative equipment sources in a deregulated, market-oriented environment, when it doesn't qualify for (or want) AAR quota orders, which could be considered an alternative car supply mechanism. The proposed process would simultaneously consider on-line car supplies, in conjunction with potential off-line car sources, in determining a road's optimal overall car supply strategy.

The Problem

If a road does not generate a sufficient number of useable empty cars on-line, either from terminated loads, receipt of empty foreigns from other roads, or the "free return" of owned (system) cars by other roads, then it must determine the most cost-effective way to obtain additional equipment in the marketplace. This additional equipment may be either owned or non-owned. With or without bilateral agreements, a road needing additional cars can expect a wide choice of equipment available to it—at a wide range of prices and costs.

**Freight Equipment Management Program, Association of American Railroads*

Just as a number of roads already use computerized techniques to select the "best" cars from an on-line supply for loading (Association of American Railroads, 1976), the next step is to expand this selection process to include off-line equipment, when necessary (i.e. when the on-line supply of equipment becomes insufficient). Traditionally in this case, roads have requested the AAR for the return of owned cars, but to the extent other roads impose empty return charges, this default mechanism may prove to be unnecessarily burdensome in the future. In many cases requesting the return of owned cars may be the most profitable strategy, but this cannot be assumed a priori.[1] Programming the necessary decision and optimization logic and development of the required data bases would allow accurate assessment and implementation of the most cost-effective strategies.

Information System Requirements

To determine most effectively the "best" cars to requisition in any specific instance and how to distribute them, data must be gathered for a number of different parameters. For loads, cars demanded, or simply "demand," these are:[2]

—location, possibly aggregated by region
—time, possibly aggregated by day
—car type

For cars "available," or "supply," these are:

—location, possibly aggregated by region
—time, possibly aggregated by day

For the cost file, which is used to match supplies to demands, these are:[3]

—distance and time on each railroad between each potential supply location and each potential demand location
—transportation cost rate (e.g. "mileage charge") by railroad

A related set of data, which would enable a railroad to obtain additional empty time and mileage savings, is a car type substitutability matrix. This matrix is a table which indicates when one particular car type is partly compatible with, or may be substituted for, another. For example, this table might indicate that if a grade B car is required, a grade A car may also be supplied if one is available and can be supplied at lower cost. (Of course, it is unlikely that it would be allowable to substitute a grade B car when a grade A car is requested, but this type of decision is the province of each individual road.)

It is proposed that TRAIN II, the industry's information system, be adapted to fulfill these information needs. Virtually all of the requisite framework for the required information is already in place in TRAIN and UMLER (Universal Machine Language Equipment Register). The necessary additions would largely be new fields such as to designate equipment availability. A conversion to a real-time mode, which is already under discussion, would also be required. As an alternative to the use of TRAIN and UMLER, roads could electronically communicate directly with each other, such as via message switching, but this alternative would lack the uniformity which could be achieved with a common industry system.

Theoretically, each distinct supply and demand should be considered individually in the optimization process. However, the number of arcs needed in the optimization (based on all potential combinations of each variable, such as location, car type, time, etc.), multiplies very rapidly. For example, a typical large railroad might easily have hundreds of supply and demand locations, a dozen car types, and a similar number of time periods to consider. This results in several million potential arcs, or more. While not beyond the capability of a medium- to large-scale mainframe computer to solve, the computation cost is more than what is likely to be deemed acceptable on a daily basis.

Thus, in practice, some aggregation of information is necessary. In general, aggregations should be made such that units with similar attributes are grouped together. For example, all loading demands or car supplies within a 24 hour period might be considered to be of the same time period. Likewise, loads or cars within an arbitrary region or area might be grouped together geographically, the assumption being that smaller distance differences are not critical.

Some aggregation must also be made of supply and demand car types. Ideally, these groups should be as broad as possible, but they don't often turn out to be very broad, because all demands and supplies must be interchangeable within a group. That is, any car in a group must be able to be used for any demand in that group. Each road must consider the requirements of its shippers in constructing this car group table. Typical factors which would be considered within an overall car type would include length, door size and car grade.

The above-described information enables the selection of the best alternative car supply sources by considering all relevant factors. This information can either be passed to a computerized optimization model (discussed in the Appendix) or to a car distributor for manual response. While the first

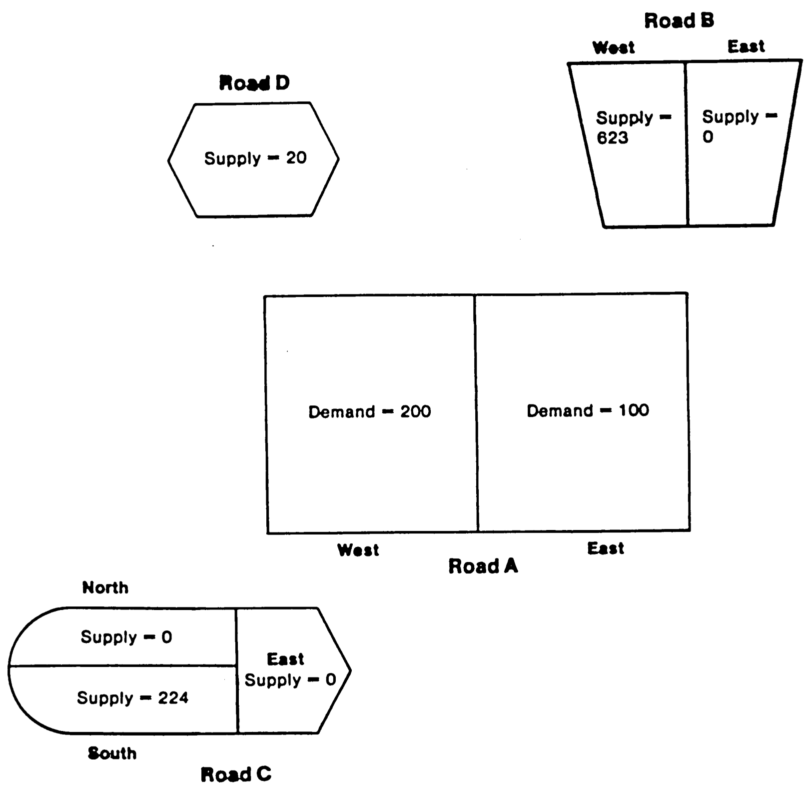

EXHIBIT 1. Optimal cff-line car sourcing under deregulation: example supply and demand

(computerized) option is the more sophisticated, it is expected that manually performed car distribution could also be improved with this information, given that the decision maker would have much easier access to, and a clearer picture of, all his possible alternative choices and their respective costs.

The total cost of each alternative supply choice is calculated by considering each of the above-listed factors (distance, ownerships, car hire costs, etc.) for each possible supply/demand match. This is explained in the simple example which follows.

Example

Road A estimates that it will need, over and above what it would otherwise generate, 200 fifty-foot double-door cars on the western region of its system, and 100 similar cars in its eastern region. (See Exhibit 1.) Road A has bilateral agreements with Roads B, C, and D, but not Road E (not pictured). Road E will not make available any cars to Road A. Road B indicates it has 623 cars available on its western region, but none on its eastern. It will move them to Road A for $ .25/car mile, the average distance of which is 258 miles. Road C has 224 cars available in its southern region, which it is willing to move for $ .30/mile, which would be an average distance of 150 miles per car. Road D is willing to move cars free of charge to Road A, but it only has 20 cars available.

From Road A's junction with Road B's western region, Road A incurs an average of 100 on-line miles and 1.5 days to its eastern loading points, which have been aggregated into a single theoretical "location," and 350 on-line miles and 3 days to its western loading points (also aggregated). From C's southern region, it is 400 on-line miles and 3.5 days to A's eastern originations and 112 miles and 1.5 days to its western ones .From its junction with D, A's distances are 300 miles and 2.5 days to its eastern originations, and 88 miles and 1 day to its western loading points.

The average per diem costs of the cars available on Roads B, C, and D are $12, $14, and $8.50, respectively. Assume Road A determines its on-line movement cost to be $ .20/mile.

For simplicity, also assume all these available cars can be moved to loading points on Road A in sufficient time to meet its expected demands. Also for simplicity, assume none of these cars available on other roads belong to Road A. How owned cars are considered is included in the discussion of the optimization model in the Appendix.

In sum, the costs to A of each alternative supply

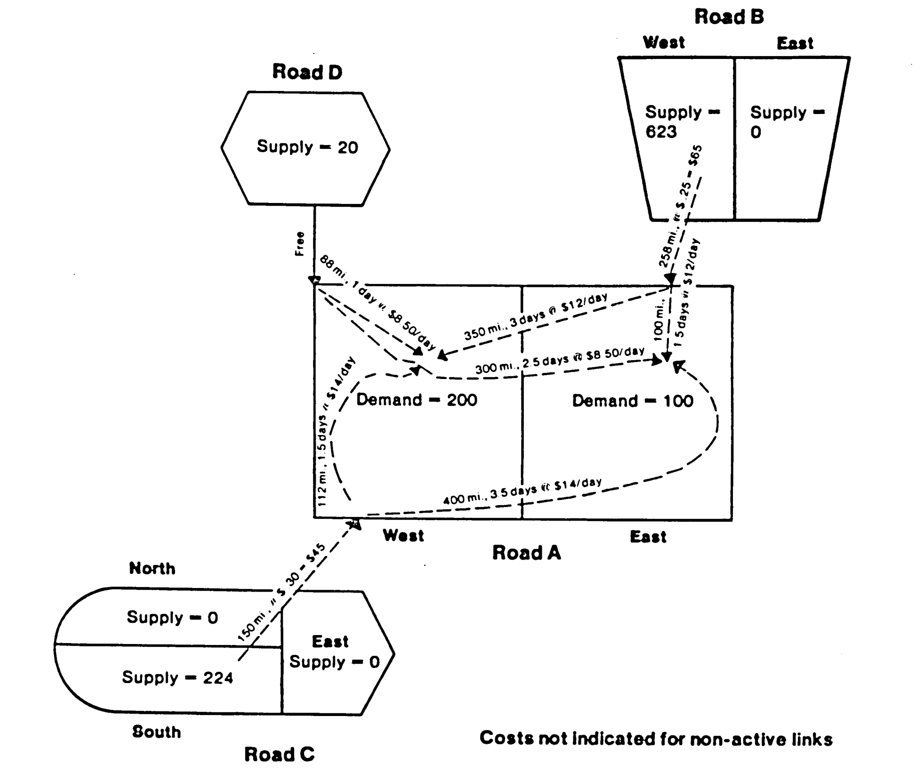

EXHIBIT 2. Optimal off-line car sourcing under deregulation: example cost factors included.

source are added up. These costs, which are easily derived from the data depicted in Exhibit 2, are:

—per diem paid to car owners for on-line time
—on-line transportation costs
—off-line transportation costs to Roads B or C (Road D offers it free)

These totals constitute the cost matrix, below:

Cost Matrix (in $)

FROM RR (Region)	**TO POINT/REGION ON RR A**	
	EAST (1)	**WEST (2)**
B(EAST)	222*	315*
B(WEST)	103	171
C(EAST)	140*	46*
C(NORTH)	155*	73*
C(SOUTH)	174	88
D	81	26

*These costs are not shown in Exhibit 2.

A real world application would be much larger than this example,and would thus have a proportionately larger cost matrix, and supply, demand, and output files, which are discussed below.

This cost matrix is for specific points or regions of Railroad A's system which it would use in minimizing movement cost. These costs reflect the miles on- and off-line for each movement, multiplied by the cost rate incurred by Railroad A for each. Added to this figure are the on- and off-line times for each movement, again multiplied by the cost rate incurred by Railroad A for each. (There might be a separate table for each car type, due to their differing car hire rates.)

The demand matrix which would be imput to an optimization model is as follows:

Demand

RR (REGION)	**Car Type** 50′ Double Door Box	(also other car types in actual application)
A(EAST)	100	
A(WEST)	200	

Road A determines (either by communicating directly with other roads or through the industry's TRAIN information system) that the following quantities of cars are available at given car hire and movement rates, which it would input as supply to the optimization model:

Supply

RR (REGION)	**Car Type** 50′ Double Door Box	(also other car types in actual application)
B(EAST)	0	
B(WEST)	623	
C(EAST)	0	
C(NORTH)	0	
C(SOUTH)	224	
D	20	
E	0	

Running the optimization model would determine the least cost combinations to meet all possible demand and would quickly return the output recommendations, which would look like this:

Output Flows

TYPE: 50 foot double door box

FROM RR (Region)	**TO POINT/REGION ON RR A**	
	EAST (1)	**WEST (2)**
B(WEST)	100	0
C(SOUTH)	0	180
D	0	20

The sum of cars distributed in the output tables (one for each car type) would satisfy, at least cost, the car demand. (In this simple example, there is only one car type.) A user-friendly format would clearly depict the recommended car flows, together with the total costs for the recommended strategy. In this example, the optimization suggests Road A request 180 cars from C's southern region for use in A's western territory, and the 20 cars available from Road D, also for use in its west. Its eastern demands should be met with 100 cars from B's western region.

Presumably, the total costs of this distribution plan would also be compared with alternative strategies, such as requesting the return of all owned cars only. This exercise would indicate the savings achievable from the more active equipment management role undertaken to minimize total car costs in a deregulated environment.

CONCLUSION

Net originating railroads may expect in the future to have to play a more active role to ensure obtaining adequate supplies of deregulated railcar equipment at minimum cost. The current process of negotiating bilateral agreements is a major step in that direction, and the presently proposed concept is an extension and refinement of that process, geared to assuring a more finely tuned, minimum cost equipment supply. Its payoff can be expected when the routine no-cost return of owned cars ceases. Such a cessation might be precipitated by higher traffic levels, or the inability of some roads to reach mutually acceptable bilateral agreements.

The keystone of the proposed dynamic (real time), minimum cost on- and off-line car distribution capability is an information system which encompasses the parameters on the supply and demand for equipment and the costs of movement. Roads may bilaterally agree with their neighbors to provide each other with the necessary information, or may pursue the establishment of common procedures at the industry-wide level, with the assistance of various AAR and Railine committees and departments.

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FOOTNOTES

1. Markowicz (1984) developed and tested a model to optimize the return of system cars only, based on their on- and off-line locations and carrier transportation rates.
2. The following data would also be necessary for a more sophisticated application, but could probably be omitted otherwise, and will not be discussed in the test. For demand, these are:
   - destination area and off-junction, if any
   - car type
   - car ownership
   - price (generally car hire cost), possibly aggregated by ownership and car type
   - storage/non-storage state for owned (system) cars
3. The following data would also be necessary for a more sophisticated application, but could probably be omitted otherwise, and will not be discussed in the text. For cost, these are:
   - distance and time on each railroad between each demand and its destination, possibley aggregated by region and railroad
   - likelihood of the car being stored or return charges applied after unloading

APPENDIX

Optimization Model

To determine which of the many possibilities of supply and demand car types, days, and locations should be matched with each other in an optimal fashion is not a trivial task. Much effort has been devoted to developing optimization models to solve these generic types of problems, and one developed by Glickman (1984) is recommended as specifically appropriate.

A road's objective is to minimize its costs, such that it covers its demands at all locations and in all time periods. These costs consist of on-line and off-line transportation and car hire costs. Transportation costs include mileage, switching, etc. Car hire costs are equal to the market car hire rate multiplied by the length of time cars are on-line (or as may be otherwise agreed). On-line demands for cars vary by car type, location and time period. The total supply of cars on-line and off-line which (a) can be substituted for a given car type and (b) can reach the location of a demand by the appropriate time period, must be at least equal to the demand in question.

The off-line mileage cost and on-line car hire rates, as well as the car availabilities themselves, are market determined: The alternative uses car owners can find for their equipment, as well as the terms of any bilateral agreements that may be applicable, will determine the conditions of equipment availability. As indicated in the text, this information would be obtained by the potential lessor road by (preferably electronically) querying other potential supplier roads, or perhaps through an information clearinghouse, such as ULMLER/TRAIN. Of course, this process requires current, continually updated data on the status and location of owned cars. Distances and costs would be considered from areas of availability to areas of need. Mileage matrices are already available in the railroad industry which would include much of this needed information.

The optimization model consists of a linear objective function for total cost which is minimized subject to a set of linear constraints stating that each demand must be satisfied. The model implicitly considers the differential implications between the transportation and car hire costs of using foreign cars and those costs associated with the return of off-line owned cars. That is, the model would retrieve an owned car when it is at least as cost effective to do so as any other car ownership.. It assumes an owned car returned on-line displaces a foreign car for an equivalent number of car days.

The total cost to a road of retrieving owned cars depends on whether or not they are in storage off-line. If an owner requests that its cars in off-line storage be moved home, it earns receivables for their future off-line days in service before their return to storage, multiplied by the market car hire rate for those cars. For equipment not in off-line storage moved home, the owner also essentially earns receivables for their on-line days (at the market car hire rate), in that it avoids equivalent payables for foreign equipment. The impact on the loaded off-line forwarded portion of a car not formerly in storage is zero because here this action has no incremental effect—the owner would receive market car hire regardless. However, it might be desirable to include a probability factor to take into the account the likelihood of a car not in storage being put into storage.