Practical Methodology for Freight Forecasting

FREDERICK W. MEMMOTT AND RUSSELL H. BOEKENKROEGER

A practical and workable technique for preparing freight forecasts, which may be used in addressing freight-related problems at the state or subregional level, is described. The flexibility of the overall approach and technique is demonstrated by examples of the use of the technique drawn from two recent studies. The structure of the process involved in using and adapting the technique is described. The importance of following prudent and pragmatic research principles is emphasized. Special attention is given to providing detailed information on each of the components of the technique.

Although freight demand forecasting is far from a new subject area, the techniques developed to date have not generally been in a form suitable for immediate application by states to freight-related problems. All too often, the techniques that are available (a) are not directly applicable to the problems being faced today by states, (b) require a level of education or understanding of modeling and mathematical procedures beyond that typically available today within state transportation or highway agencies, or (c) are simply not adequately documented (1-6). Furthermore, examples of their application to real problems are not readily available. Until now, it has been felt that such technology and examples would eventually evolve through further research and that the main need was for funding (and time).

Meanwhile, the world has not stood still. The formation of transportation agencies in a majority of states and heightened interest in multistate, state, and regional transportation systems planning have created a growing need for techniques with which to quantitatively address freight-related problems. Recent passage of deregulation legislation is bringing about unprecedented change as carriers seek to exploit new opportunities and eliminate unprofitable services. At the same time, there is an increasing awareness of the need to stop looking at problems in an isolated sense (e.g., abandonment of a seldom-used rail line) and to address the much wider range of potential problems and issues arising from the greater freedom and competition brought about by the deregulation legislation. This is virtually impossible without an easily understood, practical freight demand forecasting technique.

PRACTICAL FREIGHT FORECASTING APPROACH

The freight demand forecasting technique discussed in this paper is an adaptation and generalization of a rather simple and straightforward methodology that we have applied in several recent freight studies. It emerges from a philosophy that emphasizes substantive knowledge and understanding of a given situation in interpreting related, practical problems rather than relying on interpretations grounded solely in economic or econometric theory. The technique is really more a process for systematically making a large number of revenue and/or cost calculations than a formal mathematical model.

First, the methodology--which, for lack of a better title, is referred to as a transport costing model--is briefly described. Its usefulness and flexibility are then illustrated with examples drawn from two applications of the technique (7,8). One application involves the conduct of a reconnaissance-level study of an "All-American Navigation System" connecting the Great Lakes with the Eastern Seaboard to determine maximum potential traffic diversion to 13 alternative canal routings or physical configurations from the existing Great Lakes-St. Lawrence Seaway inland waterway system and overland to a tidewater port.

The second application involves a grain subterminal study for the State of Montana to determine quantitatively the economic feasibility of modernizing Montana's grain transportation system by using subterminals to gain the efficiencies of centralized collection and unit-train movements. In this case, feasibility depended on whether the proposed subterminals could generate sufficient economic benefits for grain growers (reduced "charges" for transportation resulting in higher prices for wheat) and additional profitability for transportation companies. This technique has been found to be flexible and adaptable to the wide range of problems increasingly being encountered by states in dealing with freight transportation.

COSTING MODEL

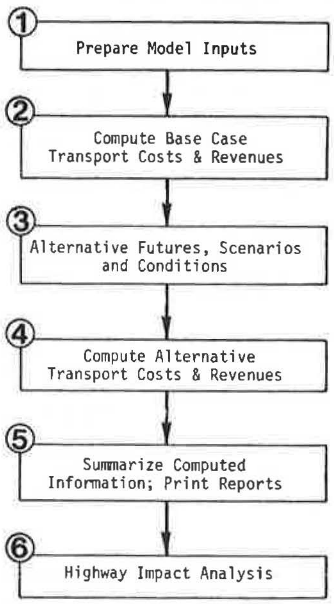
Structure

Conceptually, the freight forecasting procedure or costing model presented here is relatively simple and straightforward. For each commodity movement or flow, the process involves systematically computing and then comparing costs and revenues associated with two or more routings between points of commonality. The first routing is the null situation or base case. Subsequent routings consist of the hypothesized or forecast conditions being examined. These routings will never totally displace the first, since there will always be some traffic that will not be affected. At each stage, information on the cost of providing the transport-terminal service and the revenues derived therefrom by the transport company (or the rates and charges levied on the purchaser of the transport service) is developed and accumulated. In effect, the costing model is nothing more than a systematic procedure for making a large number of revenue and cost calculations that, in the aggregate, provide insight on the traffic, revenue, and cost changes expected to be brought about by the hypothesized or forecast condition.

The basic structure of the model is shown schematically in Figure 1. The first component simply prepares the data required in applying the model. The second and fourth components represent the heart of the model and in practice can be performed simultaneously. Data for each commodity flow are sequentially processed, revenues and costs are computed by using the base case and each hypothesized or forecast alternative, and decisions are made between routing possibilities. In the fifth component, information on commodity flow, revenue, cost, distance, and vehicle volume is summarized. The last component is likewise optional and involves determining highway impacts caused by potential changes in truck volumes expected to occur along the major segments of a state's highway system.

As used in this paper, a model is simply an objective process for determining transport costs, revenues, and throughputs under different assumptions. The focus of this paper is on the principles and concepts involved and their general application. The problems and issues likely to be encountered by individual states vary immensely, which makes it necessary to adapt the principles to the particular application at hand. In some cases, this involves the preparation of computer programs; in other cases, the techniques could be accomplished by hand calculations. Which components of the process are selected and how the computations are made can only be determined once the problem or issue to be addressed is known.

Figure 1. Costing model structure.

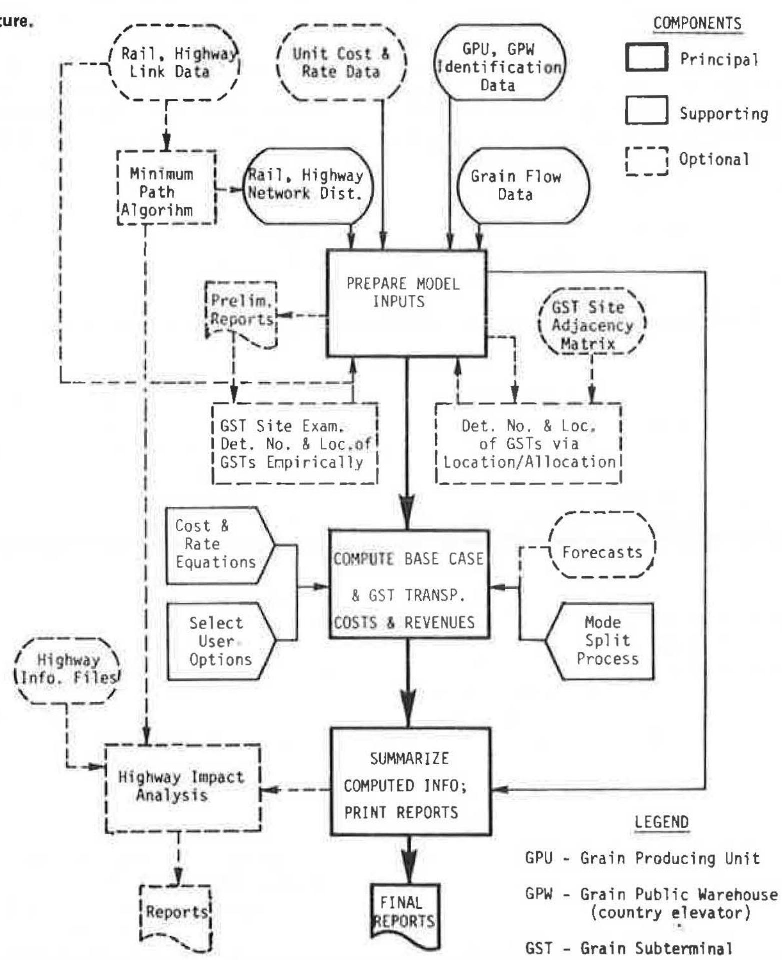


This structure can be modified by adding or combining components, as shown by the flowchart of a grain transport model in Figure 2 (9). Depending on the options selected, the model can have a recursive structure (i.e., feedbacks can be used to optimize a parameter). This would occur in the model if (a) unit costs and revenues are treated as a function of throughput volumes, such as would occur in terminal operations, and (b) the user is seeking to optimize the number and location of terminals. Although an optimizing process can be designed, there is no corresponding guarantee of producing more useful results. Optimizing models can only handle objective measures. Consequently, they can only discriminate between good and bad terminal locations in terms of their physical suitability and site development costs. Although it is possible to quantify other important criteria such as long-standing commercial trading relations and include them in optimizing models, the procedures by which this is generally accomplished belie the underlying processes involved.

Initial Inputs

The two main inputs are a commodity flow matrix and unit cost and rate data. Depending on the particular application, the flow matrix or unit costs and rates used in examining an hypothesized alternative may differ from that used in computing the revenues and costs of the base case. Other inputs, such as distances and identification data, are also required. Because the preparation of these data is

Figure 2. Grain transport model structure.



straightforward, they are not discussed in detail in this paper.

Commodity Flow Matrix

One of the most time-consuming and troublesome tasks occurs right at the beginning: developing the commodity flow matrix. Conceptually, this step is no different from preparing the "trip table" for use in highway traffic assignment work. However, the freight world introduces complications in the form of (a) different commodity types, (b) different modes or mode combinations, (c) individual corporate entities providing services, (d) stability of marketing patterns (i.e., the quantity moved between specific origin-destination pairs), and (e) the service factor. Yet, a four- or five-dimensional array is not a particularly workable solution.

The most straightforward procedure is to reduce the above down to a two-dimensional array in which commodity, modal, institutional, marketing, and service variations have been collapsed into a composite attribute vector and are treated as alternative routings between points of commonality--namely, the origin and termination of the movement or flow. Roger Creighton Associates, Inc., has found that, through consolidation and elimination of minor and relatively unimportant movements, enough simplification can be done to make the problem fully manageable. Examples of this simplification are presented below.

In the U.S. Army Corps of Engineers study (7), the commodity flow table was set up on a Bureau of Economic Analysis (BEA) domestic port to foreign port basis, with one port representing a trade route. Domestic ports were likewise limited to major Great Lakes, river, or tidewater ports. Commodities were restricted to six generalized groupings. Modes or mode combinations were limited to three: ocean shipping via the St. Lawrence Seaway; barge transport to New Orleans and Baton Rouge, transferring to ocean shipping; and rail to tidewater port, transferring to ocean shipping.

In the Montana study (8), the commodity flow table consisted of 188 origins (termed grain-producing units) and five mode-destination combinations consisting of rail-export, rail-domestic, truck-domestic, and two variations of truck-barge-export. In preparing this table, movements that did not have subterminal/unit-train potential (i.e., nonwestbound wheat and all barley) were first eliminated. Movements through each of the 230 county elevators were treated as routing alternatives of the more basic movement. Movements bypassing county elevators ("track buying") were excluded.

There is no quick, simple method of preparing the commodity flow matrix. Much depends on the particular problem at hand and data availability and quality. Preparing a commodity flow matrix is always a struggle. Because information on origin and terminating volumes is usually more readily available then information on the flows themselves, a distribution algorithm may have to be used to approximate the flows taking place. If there is any key, it is to keep the matrix as simple as possible by retaining the important movements and rejecting the relatively unimportant ones. One always finds problems with data that can only be corrected by playing detective, applying common sense, and making intelligent estimates to fill the gaps. No matter how good the data may appear to be, a great deal of time must still be spent in supplementing, cross-checking, and reconciling differences among data sources.

Unit Costs and Revenues

Equally important (and time-consuming) is the process of developing the cost and revenue relations or estimating equations to be used in conjunction with the commodity flow matrix. The chief ingredients in these estimating equations are the unit costs or rates developed by the user.

Cost and revenue relations or estimating equations generally have the following format:

$$R_1 = \text{(volume) (distance) (unit revenue/charge)} \quad (1)$$

$$R_2 = \text{(volume) (unit revenue/charge)} \quad (2)$$

$$C_1 = \text{(volume) (distance) (unit cost)} \quad (3)$$

$$C_2 = \text{(volume) (unit cost)} \quad (4)$$

where

R = revenue or change,
C = cost,
1 = a physical movement through space (e.g., transport company), and
2 = terminal, transfer, or warehousing services (e.g., grain elevator).

Variations in these basic relations come primarily in the form of differing unit revenues and costs, which reflect modes, commodities, competing companies, and even service differences. When combined together, individual mode relations or estimating equations produce an estimate of total revenues and costs, such as that used in the Montana study:

$$R_b = V_b\,[R_1 + R_3 + R_4 + R_6 + R_7] \quad (5)$$

$$C_b = V_b\,[C_1 + C_3 + C_4 + C_6 + C_7] \quad (6)$$

$$R_{alt} = V_r\,[R_1 + R_3 + R_4 + R_6 + R_7] + V_s\,[R_2 + R_5 + R_6 + R_8] \quad (7)$$

$$C_{alt} = V_r\,[C_1 + C_3 + C_4 + C_6 + C_7] + V_s\,[C_2 + C_5 + C_6 + C_8] \quad (8)$$

where

Item	Volume	Total Revenues	Total Costs
Base case (through GPWs)	V_b	R_b	C_b
Alternative (GST portion)	V_s	R_s	C_s
Scenario [GPW portion (residual)]	V_r	R_r	C_r

and where (in Montana, for example)

Mode	Revenues/ Charges	Costs
Line-haul		
Single-car rail	R_1	C_1
Unit train	R_2	C_2
Grain truck	R_3	C_3
Barge	R_4	C_4
Feeder service		
Collector truck	R_5	C_5
Farm truck	R_6	C_6
Terminal services		
GPW	R_7	C_7
GST	R_8	C_8

It is well to remember that the results obtained through application of cost and revenue estimating equations are only as good as the quality of the inputs; hence, there is a need for very careful reasoning and cross-checking in developing unit charges or unit costs to minimize the possibility of unintended distortion of the resulting answers. One can make the above equations as complex as one likes providing that the fiscal and data resources available permit this to be done. We prefer to keep such equations as simple as possible, concentrating instead on ensuring that the parameters used are correct. Again, what is done depends on the specific application.

For unit revenues, it is recommended that a matrix of established rates (one corresponding to each possible movement in the commodity flow matrix) be used where possible rather than develop special rate-estimating equations. The reason for this is that it accounts for the abnormalities that have crept into common-carrier tariffs and rates over the years that cannot be reasonably reflected in generalized estimating equations. However, often this cannot practically be done and approximating relations must at times be used instead.

For example, in the Montana study (8) single and multiple car rates for wheat moving west to Pacific North Coast ports were used. Truck rates for line-haul service were derived from the rail rates (undercut rail by 3¢ to 3¢/bushel). Truck rates for collector service were obtained from several in-state cooperatives that are literally dictating to grain truck owners the maximum they are willing to pay for hauls of different lengths. A revenue estimating equation was developed for county elevators based on "maximums" established by the State for storage and handling plus information on storage capacity and annual throughput. Barge rates were obtained through direct inquiry.

For unit costs, the following generalized procedure is recommended:

1. If sufficient time and fiscal resources are available, then it is possible to dig out rather detailed information on the modal or competitive organizations, infrastructure and equipment, and general economics involved in providing transport services. Such research is typically carried out on a sample basis by using in-depth interviews with traffic managers and accounting personnel to obtain information from which to derive unit costs.
2. If the transport or terminal services are provided by multiple firms, there obviously are multiple unit costs. These costs, known to businessmen, are not the type of information that is readily furnished to the public sector simply because accidental disclosure could adversely affect competitive relations.
3. In such circumstances, additional assumptions regarding organization, infrastructure and equipment (e.g., age, payload capacity, cost, depreciation, labor inputs, energy inputs, and operating efficiency), and utilization may have to be made before an attempt is made to estimate unit costs.
4. In developing unit costs within a limited budget, one is forced to rely primarily on telephone conversations, secondary information, and professional judgment to identify and refine cost components, which are then combined to produce a unit cost. Once a reasonable value has been established, it must be carefully cross-checked with related information as well as reviewed and discussed with persons who are knowledgeable about such costs to obtain outside opinions as to its overall reasonableness. Only then should the unit cost be used.
5. Even if the transport service is provided by a single firm, it is still usually necessary to independently estimate costs simply because of the reluctance of private companies to share such information with government.
6. There is a varying amount of published and unpublished information available on unit costs--some good and some not very useful. The tendency on the part of those not very experienced in freight studies is to latch onto such information and consider it as gospel without realizing its true source, its strengths and weaknesses, and whether it is indeed applicable to the situation at hand. It is absolutely necessary to undertake an in-depth investigation to modify secondary information before it is used in a cost-estimating equation. Often this is not done.
7. The simplicity or complexity of the unit cost is partly determined by whether the components themselves are being treated as variables. This occurs if the costing model must be sensitive to variations in the cost of capital, labor, and/or energy.

In the Corps of Engineers study (7), we somewhat reluctantly used unit cost estimates developed by the U.S. Maritime Administration and the Corps of Engineers for U.S. and foreign flag vessels of different types and sizes. At the time, we did not have sufficient fiscal resources to go as deeply as we would have liked to in estimating vessel capital and operating costs and fleet mix so as to be totally comfortable with the derived equations. Nevertheless, we were later told by the special panel set up by the Corps of Engineers that our unit costs were essentially comparable to theirs. For barge traffic, we used data we had primarily developed through queries to barge companies that use the New York State Barge Canal System. Inland waterway unit costs were developed by carefully updating previous estimates prepared by a major railroad in direct competition with barge companies on the Lower Mississippi. Rail unit costs were derived by using standard Interstate Commerce Commission (ICC) procedures.

In the Montana study (8), farm truck unit costs were derived on a per-mile basis from the ground up by using assumptions on mileage, cost, life, fuel consumption, price, etc. Grain truck unit costs were derived by reworking some fairly good up-to-date operating cost data obtained from a trade organization to fit the Montana situation. Estimating truck costs demands extreme care because the information resources are just not that good and variations in equipment investment, annual mileage, and backhaul utilization significantly affect the results. Rail unit costs were estimated by using ICC procedures (10) modified to fit a car mix situation. County elevator costs were derived by carefully reworking an earlier U.S. Department of Agriculture study (11) and from recent testimony of elevator operators seeking regulatory revisions of maximum storage and handling charges.

Computing Transport Costs and Revenues

The heart of the model lies in a series of basic cost and revenue relations or estimating equations--one applicable for each commodity-flow/routing possibility. A number of variations of this theme are described below in generalized form:

$$C^a_{mij} = V^a_{mij} (D^a_{mij} c^a_{mij}) \quad (9)$$

$$R^a_{mij} = V^a_{mij} (D^a_{mij} r^a_{mij}) \quad (10)$$

where

C = total transport costs,
R = total transport revenues or charges,
V = volume of commodity moved over some specified period of time,
D = distance between i and j,
c = unit transport costs,
r = unit transport charges or revenue,
a = a specific commodity or commodity group (a = 1 to t),
m = mode of transport from i to j (m = 1 to s),
i = origin zone (GPU location) (i = 1 to q), and
j = destination zone (market) (j = 1 to p).

In the above equations, V^a_{mij} defines the movement of commodity a between origin i and destination j via mode m. With more complex mode and routing possibilities, the basic relations must be modified to incorporate components or portions into a complete movement.

$$C_{ij}^{a} = \sum^{s} V_{mij}^{a} [(D_{mij}^{a} c_{mij}^{a}) + T_{mi}^{a} + T_{mj}^{a} + T_{ml}^{a}] \quad (11)$$

$$R_{ij}^{a} = \sum^{s} V_{mij}^{a} [(D_{mij}^{a} r_{mij}^{a}) + T_{mi}^{a} + T_{mj}^{a} + T_{ml}^{a}] \quad (12)$$

where m = 1 to s and T denotes the unit transfer or terminal charge or cost that can occur at the origin, termination, or intermediate points of the movement (the latter is indicated by the subscript l).

Equations 11 and 12 depict the total cost and total revenue, respectively, for the situation in which there is a combination of transport modes (hence, the summation over all modes m) with both end-point and intermediate terminal operations.

This can be extended further to account for multiple firms by adding a superscript b, as illustrated below:

$$C_{ij}^{ab} = \sum^{s} V_{mij}^{ab} [(D_{mij}^{ab} c_{mij}^{ab}) + T_{mi}^{ab} + T_{mj}^{ab} + T_{ml}^{ab}] \quad (13)$$

$$R_{ij}^{ab} = \sum^{s} V_{mij}^{ab} [(D_{mij}^{ab} r_{mij}^{ab}) + T_{mi}^{ab} + T_{mj}^{ab} + T_{ml}^{ab}] \quad (14)$$

where m = 1 to s, all subscripts, superscripts, and variables are as indicated above, and b is a superscript denoting an individual firm.

Putting it all together, total costs and revenues for the state would be computed as the summation over firm, commodity, mode, and geographic origin and destination:

$$C = \sum^{q} \sum^{s} \sum^{t} \sum^{u} \sum^{p} V_{mij}^{ab} [(D_{mij}^{ab} c_{mij}^{ab}) + T_{mi}^{ab} + T_{mj}^{ab} + T_{ml}^{ab}] \quad (15)$$

$$R = \sum^{q} \sum^{s} \sum^{t} \sum^{u} \sum^{p} V_{mij}^{ab} [(D_{mij}^{ab} r_{mij}^{ab}) + T_{mi}^{ab} + T_{mj}^{ab} + T_{ml}^{ab}] \quad (16)$$

where i = 1 to q, m = 1 to s, a = 1 to t, b = 1 to u, and j = 1 to p.

Fortunately, it is usually possible to simplify the general-purpose model presented above by using assumptions such as the following:

1. The commodities involved can be considered homogeneous.
2. Destinations can be limited to the principal gateways rather than the markets themselves.
3. Costs are limited to those occurring between points of commonality.
4. Inventory costs can be ignored based on the premise of a temporally uniform demand even though one is dealing with a cyclically produced commodity.
5. The intricacies of the particular business can be ignored except for the transport end.

Alternative Futures, Scenarios, and Conditions

So far, we have only considered the present or base case situation. What has to be done is to construct similar arrays to represent hypothesized futures, scenarios, or conditions.

The freight world is in a continual state of change with the rise and fall of agricultural, industrial, and extractive industry production. Markets and suppliers change and so do origin and destination patterns. Transport technologies, services, component costs, and efficiencies likewise affect modal use. In our previous work on NCHRP Project 20-8 (12), we spent a considerable amount of time examining the then state-of-the-art methodology for demand estimation and modal-choice modeling. In the present context, demand estimation can be viewed as a linkage between the base case commodity flow matrix and one expected at some point in the future. Modal-choice modeling can be viewed as changes in market shares beyond those explainable through production and consumption changes. Although considerable effort has gone into developing a methodology for demand estimation and modal-choice forecasting in recent years, much of the present methodology in these areas remains very elementary and is not yet suited for inclusion in an immediate application of a statewide freight demand forecasting technique. Although development proceeds on this front, questions must still be answered. In this regard, we prefer simpler, more direct approaches such as those outlined below.

Projecting Future Origin-Destination Patterns

Many applications do not require projections to be made, since no overall change in the origin-destination matrix is expected. Such was the case with our Montana work, where the interest lay in the changes resulting from the introduction of a more efficient mode (subterminals/unit trains). Sometimes projections can be handled simply by use of a compound growth factor, as was done in our Corps of Engineers work. There are times, though, when changing conditions dictate that a new origin-destination matrix be prepared.

If the problem is large enough, the best way of modifying the matrix is to use econometric model outputs as a guide in modifying the base commodity flow matrix. If such a model is not being used, we then encourage the pragmatic approach of informally tapping the collective intuition, estimates, and judgments of those knowledgeable in the commodities being produced or consumed. This is quite workable if the projections are relatively short range. Given good inputs, the transportation specialist can then apply this reasoning and intelligent guesses and modify the commodity flow matrix appropriately to represent expected conditions.

The longer the time frame, the more speculative is the projection. At times, it might even be worthwhile to tap the skills of experts capable of assessing where things are headed and the resulting impact on the state economy, production and consumption, employment, technology, living standards and patterns, etc. Rather than attempting to make projections mechanically, we recommend the collective "think tank" approach.

Projecting Modal Choice

The importance of modal choice will vary with the application and so will the procedure for dealing with it. Modal-choice decisions partly reflect economics and partly reflect service; the former lends itself to quantitative solutions whereas the latter does not. Introducing a new mode or mode combinations or a new service is really a routing alternative. If it costs less (revenues represent charges to the user) than the existing mode (for service of comparable quality), substitution will take place. Our technique can easily be set up to perform such a test and to reorder the traffic among modal alternatives. In so doing, the user may wish to impose two constraints on such a quantitative process: (a) a minimum threshold governing the point at which modal diversion will occur (e.g., users rarely divert just for a 1¢/ton savings) and (b) a limit on the maximum market share.

For example, in Montana the introduction of subterminals/unit trains potentially results in a sizable reduction in transport charges for virtually every movement. Were a "modal split" made on the basis of user economics, the projected outcome would have been near total diversion from the present to the proposed mode. Such drastic shifts are quite unlikely. In the end, an approach based on reasoning out what the maximum market share might be for subterminals/unit trains was used rather than an objective process based solely on savings. In this case, it was felt that there would always be a residual of low-volume, special-destination, or high-priority shipments not appropriate to subterminals/unit trains. Again, we think that it is far more important to apply careful reasoning and seek information on related or parallel situations rather than apply a quantitative modal-split process blindly.

Handling Scenarios and Conditions

Sometimes the problem is simply one of determining how much traffic might divert to one or more alternatives. This can usually be done quantitatively by adding the new alternatives as additional routings. For example, in the Corps of Engineers study, costs via 13 shallow draft barge, deep draft barge, and deep draft ship canal alternatives were computed in addition to the three existing routings mentioned earlier, and the traffic split between the alternative and base case situation was determined through determination of the least-cost routing. "What if" conditions, which include such possibilities as changes in pricing, energy availability, service, and regulatory constraints, can often be handled by the same basic process of adding and then quantitatively evaluating routings.

Summary of Results

Whereas the cost and revenue equations must be tailored to the specific issue or problem being examined, the outputs from the computational process can often be standardized. Concern generally lies in efficiency and distributional benefits potentially achieved by the alternative being examined in comparison with the base case. It is the degree of change, rather than the absolute values per se, which generally is of greatest interest to those affected.

What we like to do is to first prepare a comprehensive output record, which can then be summarized in a variety of ways. A record containing (a) control information, (b) commodity flows, (c) revenues or charges, (d) costs, (e) unit distances, and (f) vehicle equivalents would be prepared for each unique movement. Revenues/charges and costs would be further broken down into those that occur under the (a) base case, (b) alternative alone, (c) residual, (d) alternative plus residual, and (e) difference between the alternative and residual and the base case.

For example, in the Montana study, control information consisted of grain-producing unit, county elevator, grain subterminal, and market designations and origin county. Grain flow data consisted of grain that has subterminal potential and all other grains. Revenues and costs were subdivided by components: line-haul modes (single-car rail, unit train, grain truck, and barge), collector modes (collector truck and farm truck), and terminal handling (county elevator and grain subterminal). These components were then summarized to produce line-haul, collection, terminal, grain company, grower, and total revenues and costs. Distances consisted of farm to elevator, farm to subterminal, elevator to market, and subterminal to market mileage, and vehicles consisted of rail cars (covered hoppers), grain trucks, collector trucks, and farm trucks.

Although the format is admittedly long, the user can divide it into several shorter records, if so desired (or for software reasons). Once output records have been prepared, various reports summarizing the results can be prepared. Summary tables can be produced either on an aggregate or a unit basis. Either detailed or abbreviated revenue and cost summaries can be prepared. The former would be appropriate in determining the projected impact on the different modes (distributional effects), whereas the latter would be of interest particularly in preparing geographic summaries (efficiency benefits). In addition to revenue and cost summaries, vehicle-mile and ton-mile summaries could also be prepared.

Highway Impact Analysis

The previous section discussed one type of output that could be obtained from a computerized version of the costing model. The second type of output, which is optional, consists of base and alternative commodity flows (in vehicles) over each link of the transport system: rail, highways, and waterways. It is possible to design the process in such a way that programs from the Federal Highway Administration (FHWA) urban transportation planning series can be used to determine routings and accomplish the necessary accounting, provided that the state highway and county highway networks have already been coded for this purpose. Depending on how a state has organized its highway information files, it may be possible to directly use segment data on physical characteristics, condition, and use, although network inputs are usually at a macro rather than a micro level.

Three possible assessments can reasonably be made. Their positive and negative points are discussed below:

1. One approach is to summarize vehicles on a link basis and determine the differential between the scenarios and the base case. The problem with this approach is equating different types of trucks, which have different impacts on pavement structure. Consequently, a simple change in the number of vehicles with the alternative (as compared with the base case) is often meaningless.
2. Determining the change in equivalent annual load applications (EALAs) neutralizes the differences between different vehicle types, although it requires other assumptions or data on the proportion of different wheel-axle configurations, tare weights, and loadings. The problem with this approach is that differential EALA does not directly relate to pavement life. For example, a 10 percent increase in EALAs does not mean a 10 percent decrease in the remaining pavement life, since the effects of pavement age, design strength, and other traffic have not been included.
3. Another extension to the approach given in item 1 is estimating the change in service life. The data used in this process can be either very detailed information on pavement condition and structure contained in a state's highway information system files and traffic volume and classification information or various assumptions and default data developed by FHWA for highway needs studies. The problem with the first type of data is that they will not be available uniformly across the state and involve a level of detail that goes far beyond the level of planning and analysis presented in this paper. Determination of service life depends on the following factors: (a) present pavement condition (present serviceability rating or index or the equivalent); (b) pavement structure or thickness, expressed as a structural number, slab thickness, or correlation thereto; (c) soil support value(s) or

correlation thereto; (d) number of present 18-kip single-axle EALAs applied to the roadway; and (e) the average annual rate of traffic growth.

In considering the above possibilities, we conclude that most states are primarily interested in potential changes in truck volumes or truck loadings that are likely to occur in the vicinity of traffic generators and along principal truck routes. The former can be handled quite readily by reassigning vehicles back to the rail and highway networks by (a) identifying the specific links involved in minimum distance (or time), (b) assigning computed traffic vlumes to these links, and (c) summarizing the data on a link basis. Normally, this would be done separately for the base case and each alternative and the final product would be the difference in volumes and the relative change projected to take place.

CONCLUSIONS

The goal of this paper was to present and describe a technique that enables users to prepare freight forecasts in a simple and straightforward manner, deriving insights and related information on changes and impacts brought about by hypothesized or future conditions. In illustrating the use of this technique with examples drawn from two distinctly different problems and applications, it has been demonstrated that the technique is both flexible and adaptable. The framework of the technique, which consists of basic concepts and principles, permits users to organize and structure a process to examine the complex issues involved in freight-related problems. Each of the components of the technique may be expanded on to meet the particular requirements of given situations.

The approach presented encourages the user to incorporate substantive knowledge and understanding in interpreting a problem or situation as well as adapting the technique. Reliance on economic theory and econometric networks is not appropriate in analyzing many freight-related problems, and a balance must be established between what theory tells us and the way the real world behaves. In this sense, the technique is more of a process tailored to a specific situation than a standardized methodology in which only a specified set of data inputs is required to produce results.

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Development and Application of Statewide, Multimodal Freight Forecasting Procedures for Florida

DAVID P. MIDDENDORF, MARK JELAVICH, AND RAYMOND H. ELLIS

The development and application of a goods movement forecasting methodology resulting from the Statewide Multi-Modal Planning Process Project sponsored by the Florida Department of Transportation are described. The methodology involves two steps. First, the generation and distribution of freight are projected through a Fratar model that applies growth factors to current flows of commodities. In the second step, the projected freight flows are distributed among competing modes through modal-split models. The Fratar model was successfully applied to produce reasonable projections of freight traffic to, from, and within Florida in 1985 and 2000. Efforts to develop modal-split models by using the logit formulation were not successful. The Fratar model was based on existing secondary sources of data. Because these sources exist in the same or an analogous form in other states, a similar modeling approach could be developed and applied elsewhere.

State departments of transportation are becoming increasingly involved in multimodal freight planning. The reorganization of railroads in the North-