THE USE OF COMPUTERIZED RAILROAD COSTING PROGRAMS IN TRANSPORTATION MANAGEMENT AND ANALYSIS

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UGPTI Staff Paper No. 69

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February 1985

Foreword

This paper highlights some of the principal uses of rail cost data in transportation management and analysis, and describes a computer costing algorithm which can assist transportation managers, shippers, and policy analysts in the estimation of railroad service costs. Some of the ideas and material contained in this paper were originally presented (by the author) at the Agricultural Transportation Conference, January 9, 1985, in Alexandria, Virginia; a comprehensive agricultural transportation conference sponsored by the Office of Transportation, U.S. Department of Agriculture. While the focus of that seminar and the original presentation was on agricultural transportation, the context of this paper and the capabilities of the costing algorithm described within, extend to all commodities shipped by rail, not just agricultural products.

In addition to pointing out the potential uses of rail cost data, the paper outlines some of the types or classes of rail costs which can be estimated and overviews the process of railroad cost finding.

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I. Introduction

The purpose of this paper is threefold:

1. to overview some potential uses of railroad cost data in transportation management and analysis;

2. to highlight the relevance of certain aspects of the cost finding process with respect to bulk commodity shipments;

3. to describe a computer algorithm which has been developed to guide or assist transportation managers, shippers, or policy analysts in the estimation of railroad service costs.

The paper is organized as follows. First, the potential uses or applications of rail cost data are discussed, ranging from transportation/distribution planning to public policy analysis. Second, the various types or classes of cost data which can be developed are delineated, including shipment costs, rate structure costs, and line-segment costs. Third, the process of railroad cost finding itself is overviewed, from the initial stages of statistical analysis to the culmination of the process (which results in individual shipment costs). And in conclusion, the nature and capabilities of the computer costing algorithm are explored and a prospectus for its use by shippers and policy analysts is presented.

II. Principal Uses of Railroad Cost Data

2.1 Transportation Policy Analysis

Carriers, shippers and government agencies alike are concerned with and impacted by transportation policy and the rules and regulations which stem from national transportation policy objectives. Railroad policy analysis (the practice of monitoring and evaluating the performance of the railroad industry in light of national transportation policy objectives) constitutes a central element in the overall efforts of various transportation modes, shipper groups and government agencies to affect the environment in which they operate.

As will be outlined in the following paragraphs, railroad cost data can make a substantial contribution to the practice of transportation policy analysis. In order to set the stage for this discussion some of the principal railroad policy objectives, as set forth by the revised Interstate Commerce Act, are synopsized below.

2.1.1 Principal Railroad Policy Objectives

In regulating the railroad industry of the United States it is the policy of the federal government to, among other things:[1]

1. ensure the development and continuation of a sound rail transportation system with effective competition among rail carriers and with other modes;

2. foster sound economic conditions in transportation and ensure effective competition and coordination between rail carriers and other modes;

3. promote a safe and efficient rail transportation system by allowing railroads to earn adequate revenues;

4. maintain reasonable rates where there is an absence of effective competition and where rail rates provide revenues which exceed the amount necessary to maintain the rail system and to attract capital;

5. encourage honest and efficient management of railroads and, in particular, the elimination of noncompensatory rates for rail transportation;

6. prohibit predatory pricing and practices, avoid undue concentrations of market power and prohibit unlawful discrimination.

Given this framework, there appear to be some substantial areas of investigation where railroad cost data can contribute to the on-going

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[1]These policy objectives correspond to policies 4, 5, 3, 6, 10 and 11 of Title 49 U.S.C.A. Chapter 101, part 1a respectively; formally cited as 49 U.S.C.A. § 10101a.

efforts of railroad policy analysis; the principal of these include:

1. monitoring the efficiency of railroad operations and practices;

2. evaluating the effectiveness of competition in the transportation marketplace;

3. assessing the revenue needs and revenue positions of carriers in transportation markets;

4. investigating the existence of predatory prices and practices.

Each of these is briefly discussed in the following paragraphs.

2.1.2 Monitoring the Efficiency of Railroad Operations and Practices

As railroads react to changes in regulation, government promotion, industrial organization and technology it is frequently useful, from a policy perspective, to analyze trends in carrier efficiency. One measure of efficiency is the per unit cost of output. Examining changes in the cost of providing various services over time (controlling for inflation) in conjunction with productivity measures[2] can provide policy makers with an on-going picture of the reaction of the railroad industry to environmental stimuli such as deregulation, plus their reaction to changes in internal policy (such as "rationalization" of route structures and service levels), or major alterations in labor or contractual arrangements.

2.1.3 Evaluating the Effectiveness of Competition in Transportation Markets

One of the basic premises underlying the Staggers Rail Act (1980) was that effective competition, either intramodal or intermodal, existed in many transportation markets (although not necessarily all) and that such competition set limits on railroad pricing. From a public policy

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[2]Railroad capacity measures (such as miles of total road, miles of branch line track, etc.) can be gained from publicly available railroad reporting schedules, as can operating or output measures such as the number of net ton miles and train hours, as well as train and yard labor costs.

perspective, it is extremely important that those markets where effective competition does not exist be identified, and that changes which occur over time be evaluated in terms of their impacts on transportation competition. The introduction of new technologies, institutional changes (such as user fees) and changing marketing patterns or commodity demand can collectively or individually transform a competitive market into a non-competitive one, or vice versa.

One method, and perhaps the most straightforward one, of evaluating the effectiveness of competition in specific transportation markets is to examine the relationships between price and cost. If a wide divergence between price and cost persists, then there may be justification to believe that effective competition in the market does not exist. This may be true regardless of the numbers of modes or carriers participating in the market.[3]

When evaluating the effectiveness of competition in a particular market, some of the items below may warrant consideration.

1. Are the cost structures of competing railroads sufficiently different to provide one carrier or carriers with advantages over the other? This question may be particularly relevant in markets where larger carriers with a diversified traffic base are in competition with smaller carriers which are overly-dependent upon a few commodities.

2. Do rail costs in general appear to be below the rates of competing modes?

3. What is the relationship between the lowest cost railroad service level (i.e., trainload or unit train shipments) and the prevailing service levels of other modes?

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[3]The characteristics of the commodity, the size and route structure of the railroad, and other complicating factors may present the potential for a single railroad, for example, to dominate a particular market in spite of the fact that other rail carriers serve the same producing area, and other modes (such as motor carriers) are available to transport the commodity.

2.1.4 Evaluating the Revenue Needs and Position of Carriers in Markets

It is frequently of interest to policy analysts to evaluate the revenue needs of a carrier in a particular transportation market and to assess the margin of revenues above costs. Such studies provide several classes of information which total or aggregate revenue needs assessments do not provide.

First, they delineate the revenue needs of the carrier with respect to the specific classes of traffic or commodities which are carried. Because of the characteristics of certain commodities and their marketing or distribution patterns, the revenue needs of a carrier (as expressed by the full cost of service and a return on investment) may vary between markets.[4] Together with their variable or out-of-pocket costs, the revenue requirements of the carrier establish both its limitations and its long-run potential in a given market. Second, market-specific studies of revenues and costs provide a yardstick concerning the contribution to burden which is made by each class of traffic. Such information is of particular interest to commodity groups where the freight rate on their product comprises a sizeable proportion of the F.O.B. price and where their revenue contribution is substantial relative to other commodities.

2.1.5 Monitoring Predatory Pricing and Practices

Predatory practices, which are designed to remove competing transportation firms from the marketplace, fly in the face of sound economic principles and can serve to the long-term detriment of carriers and shippers alike. In predatory pricing, the rate of a given transportation carrier (or mode) drops below variable cost, temporarily, in an effort

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[4]A transportation market may be as narrow as movements for a particular type of grain from a geographically restricted producing area to a specific destination, or as broad as a pattern of movements for several grains in a broad region such as the Western Territory.

to eliminate competition. In addition to damaging competing firms, noncompensatory rates, if maintained long enough, can dehabilitate the initiating carrier or carriers. The shipping community, while the short-run beneficiary of reduced rates, is nevertheless the long-term loser as reduced competition and eventually higher rates will result in the transportation marketplace. By monitoring price-cost relationships, such movements can possibly be identified in the early stages before the rate drops below variable cost.

2.2 Public Regulation and Planning

In addition to policy analysis, which is broad and contextual in nature, the day-to-day functions of governmental agencies concerned with the regulation or promotion of railroad services depend heavily upon rail cost data, particularly in the areas of maximum rate regulation, railroad surcharges, and rail line abandonment. One of the original, and still the most straightforward measure of market dominance is the rate-to-cost relationship. Costs, in addition, have now become a matter of concern on particular routes as the Staggers Rail Act of 1980 permits joint-line and/or light density surcharges on unprofitable movements and lines. The level of the surcharge is, by law, restricted to the cost of service. The third area of regulatory oversight, rail line abandonment, has historically depended upon cost estimates, as the basic criterion for abandonment has been the revenue-cost position of the line.

In addition to federal regulation, government planning or promotion of railroad services, a concept which grew out of the financial demise of the Northeast railroad system in the late 1960's and early 1970's, is another evolving area of railroad cost analysis in the public sector. State governments, in particular, have become concerned with the viability of those portions of the railroad system which are operated within their boundaries. State governments, in certain instances, will invest public monies in transportation infrastructures or engage in operating subsidies designed to continue (or at least prolong) service over individual line segments. A knowledge of the costs associated with various railroad services and operations is therefore of central importance to state (or federal) transportation planning agencies.

2.3 Transportation Management

Prior to the passage of the Staggers Rail Act of 1980, traffic managers could depend upon the oversight of the Interstate Commerce Commission to provide an operating environment based on stable rates and regulated competition. Published tariff rates constituted a standard "price list" from which each firm purchased transportation services. Railroads operated as common carriers, offering the same or similar service levels to all shippers.

In this environment, rates which were offered to competing shippers could be determined from published price lists. Rates could be forecast, furthermore, from historical trends with a knowledge of the level of inflation in railroad factor prices. The retraction of ICC oversight, in conjunction with the expansion of multiple carload, trainload and unit train service levels, and the introduction of contracting have served to reduce stability (or increase uncertainty) and re-orient the functions of the traffic manager. These changes have, at the same time, increased the range of options available to shippers and created opportunities for reducing shipping costs in competitive markets, and for building transportation or distribution advantages among firms.

The skills and knowledge which are needed by transportation managers to function effectively in this new regulatory environment include adroit bargaining or negotiating talents and the analytical capability to produce relevant information with which to negotiate. As a leading author in the field of transportation management has suggested, "bargaining should be done from a position of power, not weakness".[5] Information becomes power in a negotiating context, lending leverage to a shipper's position. In addition to a detailed knowledge concerning distribution patterns (of the firm and its competitors), product characteristics (i.e., density and value), potential volume, possible consolidation requirements, equipment needs, rates and service characteristics of competing modes, and existing rail rate structures, a knowledge of the carriers' revenue needs (i.e., cost plus a return on investment) in transporting a shipper's product can be an "extremely important"[6] asset in negotiating rates and services. As Flood (1984) concludes:

> "...by necessity, motor and rail carriers have become more cost-oriented. Reasonably accurate knowledge of a carrier's out-of-pocket and fully distributed costs provides the shipper with essential facts for negotiating reasonable rates. The knowledge of the carrier's needs provides a reasonable understanding of the carrier's limits, a distinct advantage for rate negotiations. Consequently, transportation personnel should improve their costing analysis techniques to add to their negotiating skills."[7]

In addition to requiring cost of service data related to various shipment patterns and service levels, transportation managers must also be concerned with the future viability of particular line segments which allow access to and egress from their industrial yards or sidings. If located on a light-density branch line, transportation managers must

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[5] Transportation Management, by Kenneth U. Flood, Callson and Jablonski, 4th edition, William C. Brown Publishers, 1984, page 39.

[6] Ibid., page 40.

[7] Ibid., page 41.

monitor the status of the line segment and be able to react to potential surcharges and/or abandonments. A knowledge of the carrier's cost in providing service over particular branch lines may therefore be of direct concern to the development of strategic distribution plans.

III. Classes of Railroad Costs

The previous section overviewed some of the principal uses of rail cost data in both the public and private sectors. This section of the paper will highlight the different types or classes of rail cost data which can be estimated.

3.1 Shipment Costs

The historical focus of railroad costing has been on the estimation of shipment costs. Shipment costs are those expenses which are associated with the movement of a particular commodity between a given origin and destination in a particular car type. Shipment costs will vary with the attributes of the consignment (i.e., product density, equipment requirements, value, etc.), the level of service and the pattern of distribution.

Shipment costs may be expressed as either variable or "out-of-pocket" costs, or as "fully distributed" costs, the latter reflecting an allocation of fixed system cost to the shipment. Unadjusted Uniform Railroad Costing System (URCS) or Rail Form A (RFA) unit costs and operating factors will yield estimates of the average shipment costs for a commodity, a car-type, and a given origin-destination pair. Adjustments to average shipment variables can be made to simulate the economies associated with multiple-carload, trainload or unit train service. These service levels and adjustments will be detailed later.

Shipment costs are frequently used by transportation managers or analysts for one of the following purposes:

1. rate evaluation for regulatory purposes, either maximum rate or joint-line surcharges;

2. rate negotiation;

3. distribution analysis, such as the cost (to the carrier) of a range of different commodity flows or combinations of flows;

4. public policy analysis;

5. evaluation of "off-branch" costs in abandonment cases.

3.2 Service Level Costing

Shipment costing, as the name implies, is an effort to evaluate the cost (to the carrier) of existing product flows. Under this type of costing, the attributes of the shipment are normally assimilated from shipping records, such as the waybill or bill-of-lading, or are known from observation of carrier operations. In certain instances, however, transportation managers (or analysts) may wish to evaluate the cost associated with service levels or structures which they are currently not receiving. In such instances, they want to know the differential or comparative costs associated with single-car service as opposed to trainload or unit train shipments, for example. Such information could prove quite beneficial in negotiating a new volume rate with a carrier. The distinguishing characteristic of service level costing, then, is that it is concerned as much with cost differentials as with the absolute or shipment cost. The purpose of such analysis is normally to estimate shipment costs across a rate structure for each or several possible service levels which a carrier is capable of providing.

3.2.1 Possible Elements of a Rate Structure

In providing transportation services, railroads normally have the capability to supply a range of possible types or classes of service. Generally, all service offerings will fall into one of the following categories:

1. single-car;
2. multiple-car;
3. trainload;
4. unit train.

A unit train, as commonly defined, consists of a shipment which is part of a continuous, cyclical pattern of movement between the same origin and destination, normally involving a dedicated train set and locomotive consist. The ICC, in their reporting instructions for Schedule 755, Railroad Operating Statistics, defines a unit train as "a solid train with a fixed, coupled consist operated continuously in shuttle service under load from origin and delivered intact at destination, and returning empty for reloading at the same origin."

This definition is not synonymous with that of a trainload shipment. A trainload, although involving some of the same characteristics of a unit train, does not have to part of a broader, cyclical pattern of movement. The pattern, rather, is discontinuous in nature. A trainload shipment may consist of a one-time consignment which is never repeated.

A trainload thus may be defined as a "solid" freight train comprised of a single consignment which provides direct single-train service between origin and destination. The key operating difference between this definition and that of a unit train is that a trainload does not necessarily return empty to the same origin for reloading. A second distinguishing characteristic of a trainload is reflected in the term "solid train." Trainloads are not comprised of mixed consignments of freight. Under a trainload service option the consignment is not hauled to a regional classification yard and blocked into a through train with other consignments which must be separated at the terminating switch yard. The train constitutes a single unit which requires no intermediate yard switching or way train service.

A multiple-car shipment may be of any practical size: 3, 10, 25, 50 cars or greater. Size is not a characteristic which distinguishes a trainload from a multiple-car shipment. The key differences are: (1) a multiple-car shipment does not enjoy the same direct origin-destination service as a trainload, (2) a multiple-car shipment does not constitute a solid or separate train, and (3) for the above reasons, a multiple-car shipment may incur both consolidation and dispersion activities as well as way train handling.

A multiple-car shipment thus may be defined as consisting of any consignment of more than one car which does not constitute a trainload or solid train, but is yet large enough to warrant special handling procedures and/or a different rate structure than a similar single-carload shipment.

This generalized rate structure of 4 elements may be expanded (and it is in many agricultural shipments) to allow for the pooling or consolidation of shipments at origin. Both the multiple-car and trainload service levels (within the rate structure) may be offered as multiple-origin as opposed to single-origin shipments. Under multiple-origin rate structures, the required shipment volume (25 cars, 54 cars, etc.) may be accumulated at 2, 3, 4 or more stations instead of at one. The shipments normally may be consigned on separate bills of lading but must be consigned to a single consignee. This arrangement provides carriers an advantage over single-car shipments at origin plus decided efficiencies in delivery at destination, where the unit is classified and delivered as a single block.

In distinguishing between multiple-origin and single-origin service, the key cost element is the locomotive switching expense incurred at origin. Conceptually, single-origin shipments are more cost-efficient than multiple-origin shipments. If a 21-car consignment is switched at three stations instead of one, three separate switches of seven cars each would be required (on the average). Since the number of switching minutes per car bears some relationship to the size of the block being switched (the "cutsize"), the number of switching minutes for the shipment as a whole will be greater for multiple-origin shipments.[8] The cutsize, once calculated, can be used in conjunction with a special switching adjustment scale to approximate relative switching efficiencies.

3.3 Line Segment Costing

Both shipment and service level costing reflect the cost of service at the average level of traffic density for a carrier or region. In many instances, this provides an appropriate estimate of the mix of a carrier's facilities which a shipment utilizes. In other instances, it may not.

The need for line-segment analysis usually arises when a shipment originates or terminates on a light-density branch line, one which has a net traffic density which is considerably less than the carrier's system as a whole. Because of the light traffic density a carrier may have surcharged the traffic (or at least be contemplating a surcharge), or

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[8] The cutsize is calculated by dividing the number of carloads in the consignment by the number of originating freight stations.

placed the line on its System Diagram map. When a line is placed on a System Diagram map, it has either been identified for future abandonment, has been earmarked for study by the carrier with the intent of assessing its viability, or in the worst scenario, has an abandonment petition pending with the Interstate Commerce Commission. In either instance, the future of the line is in question.

Shippers may wish to monitor the status of a particular line segment which forms a part of their distribution pattern (as a component of a strategic transportation planning process), or to evaluate the fairness of a surcharge or abandonment petition. In either case, the concern here is with the cost of all traffic originating or terminating on a line segment, not just a particular type or class of shipment. When developing such costs, the analyst must work through a two-step process, developing both on-line or "on-branch" costs and off-line or "off-branch" costs.

Off-branch costs consist of those expenses which occur beyond the junction of the branch line with the main line (or another feeder branch line). Off-branch costs represent a modified version of shipment costing and may be derived using standard shipment costing techniques. The difference is that industrial switching costs at origin (or destination) as well as much of the way train gathering (or delivery) costs are excluded from the calculation,[9] and the costs are calculated for all traffic originating or terminating on the branch line, rather than simply one movement flow. The branch line in question is then treated separately and more specific costs for the segment are developed based on the type and frequency of service provided, the operating conditions

[9] An intertrain switch is substituted for an industrial switch.

of the branch line, and other line-specific factors.

In addition to developing direct operating costs on the branch line, the fixed capacity costs associated with the continuation of service over the branch line must also be included in the calculation. Normally the transportation analyst must have an idea of how much traffic is generated by the branch line, what that mix of traffic is, the average distance moved on the branch line, the maintenance of way expenditures including necessary rehabilitation, the opportunity cost of the land and the salvage value of in-place materials. Average values, however, can be used for several of the variables, thereby reducing the data collection requirements. Average land values for a geographic regions can be used, for example, along with average factors such as a normalized maintenance cost per mile and an average salvage value for mile of track. Such statistics may be calculated from a carrier's annual report and other publicly-accessible data. Except in the instance of opposing an abandonment application, such estimates will normally provide transportation analysts with a reasonable approximation of the on-branch costs and the future viability of the line at a low resource (data collection) cost.

3.4 Switching Costs

In addition to categories of cost discussed previously, transportation managers in particular may be concerned with the cost associated with providing certain types of switching, which carrier's may access charges separately for or incorporate as part of the line-haul charge. There are three major classes of switching which the transportation manager may be inclined to analyze. These are:

1. intraterminal switches,
2. interterminal switches,
3. industrial switching.

An intraterminal switch consists of the switch of a car or cars from the siding of one shipper to the siding of another within the same switching district on the lines of a single carrier. An interterminal switch is similar to an intraterminal switch except that here the consignment is switched from the lines of one carrier to another; that is, it must be interchanged. An industrial switch, on the other hand, involves the spotting and pulling of freight cars at the consignor's and/or consignee's siding.

A knowledge of these costs may be valuable to shippers in evaluating the carrier's switching charge(s) and in planning and negotiating switching arrangements with the railroad.

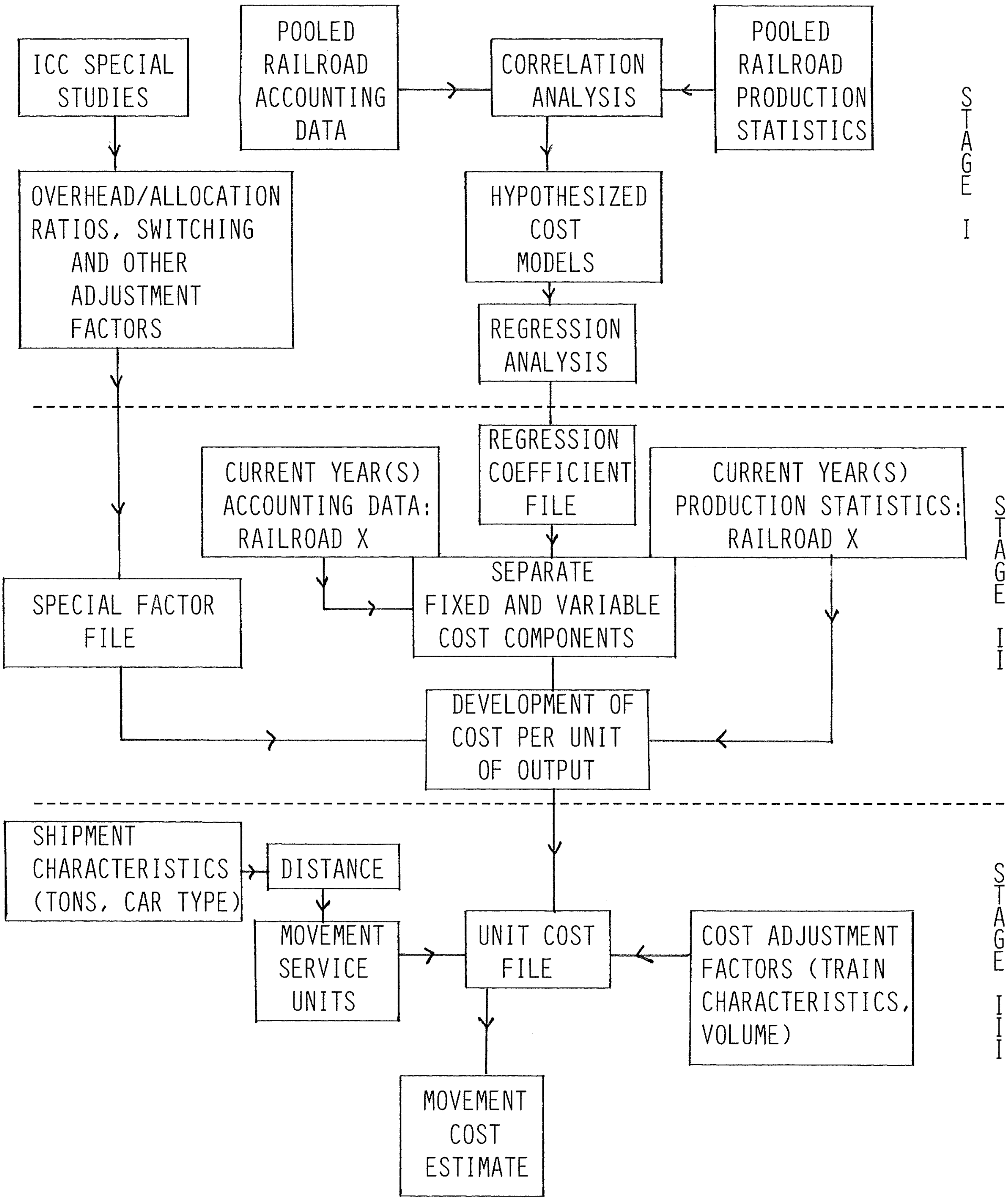
IV. Overview of the Cost Finding Process

The railroad cost finding process, as developed by the ICC and refined throughout the years, consists of three separate but interrelated stages (Exhibit 1). In Stage I, which is really somewhat exogenous to the remainder of the process, statistical studies are undertaken to determine the variability of railroad expense clusters with respect to changes in output. A series of special costing factors, in addition, which have been developed from ICC studies, are compiled and coded in Stage I. The results of the statistical analysis as well as the special study factors are then conveyed to the second stage of the process which consists of the calculation of variable unit costs for a carrier or group of carriers.

Stage I is normally of little or no concern to transportation managers or analysts. The statistical models and resulting coefficients have been

Exhibit 1

PROCESS FLOW OF RAIL COST-FINDING



developed initially by the ICC and the procedures used have been subjected to considerable public comment. It is likely, furthermore, that the ICC will continue to perform or oversee this process in the future, relieving transportation analysts of this responsibility. For those readers who are curious or strongly concerned about Stage I analysis, Appendix A of this paper provides an overview of some of the major cost-output relationships analyzed by the ICC.

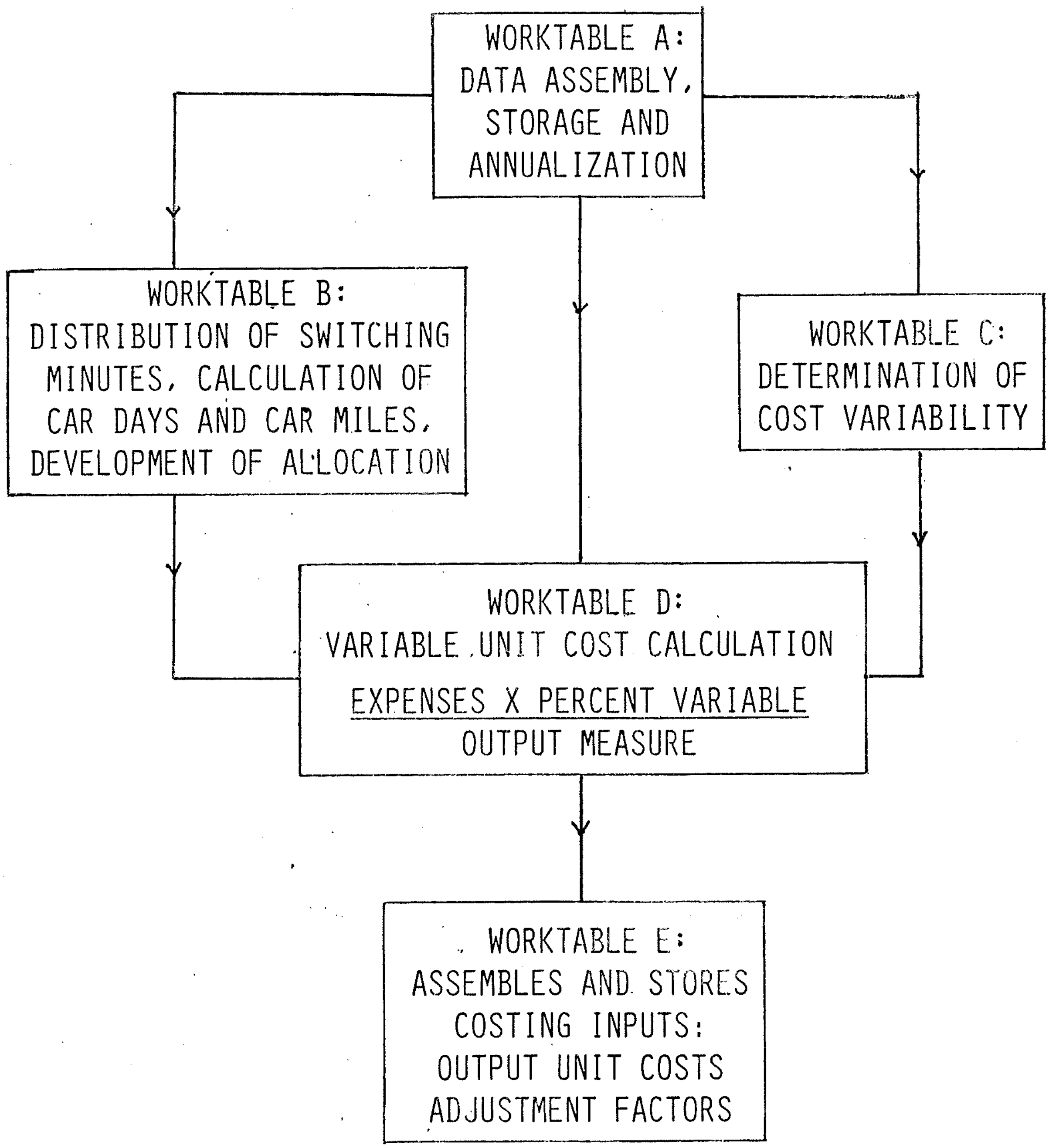
4.1 Phase II Unit Cost Calculations

Stage II of the cost finding process, which corresponds to Phase II of URCS, consists of a computer program which utilizes the regression coefficients and special study factors developed in Stage I to produce estimates of variable unit costs which are carried forth to the third stage of the process, where costs are developed for a particular shipment, service level or line segment.

Exhibit 2 depicts the flow of Phase II of URCS and the various worktables and functions involved. Worktable A serves essentially as a repository for the Phase I coeffients and variables, and contains current year expense and operating data for ICC regions or Class I railroads. Worktable B performs a variety of functions, including the calculation of the average switching minutes per car by class of switching, and the development of allocation ratios concerning the distribution of overhead and/or joint expenses. Worktable C uses the results of the Phase I statistical analysis to assign actual account expenses for a given railroad to various production or output measures, and Worktable D, drawing from Worktable C, calculates a range of variable unit costs related to various aspects of railroad service (i.e., locomotive mile, car mile and engine switching minute unit costs). A more detailed

Exhibit 2

PHASE II WORKTABLE FUNCTIONS



discussion of the process and functions of Worktable C and D, and of the calculation of the variable unit costs, may be found in Appendix B.

The results of Worktable D calculations are stored in Worktable E of Phase II. For most cost analysts, this is the only relevant worktable of Phase II; a starting point for shipment cost analysis. Once compiled for a carrier or region for a given year, Worktable E does not have to be recompiled. The file acts as a quasi-permanent data base for Stage II analysis, and must be modified only when the costs become outdated or if the underlying assumptions change.

4.2 Shipment Costing Methodology

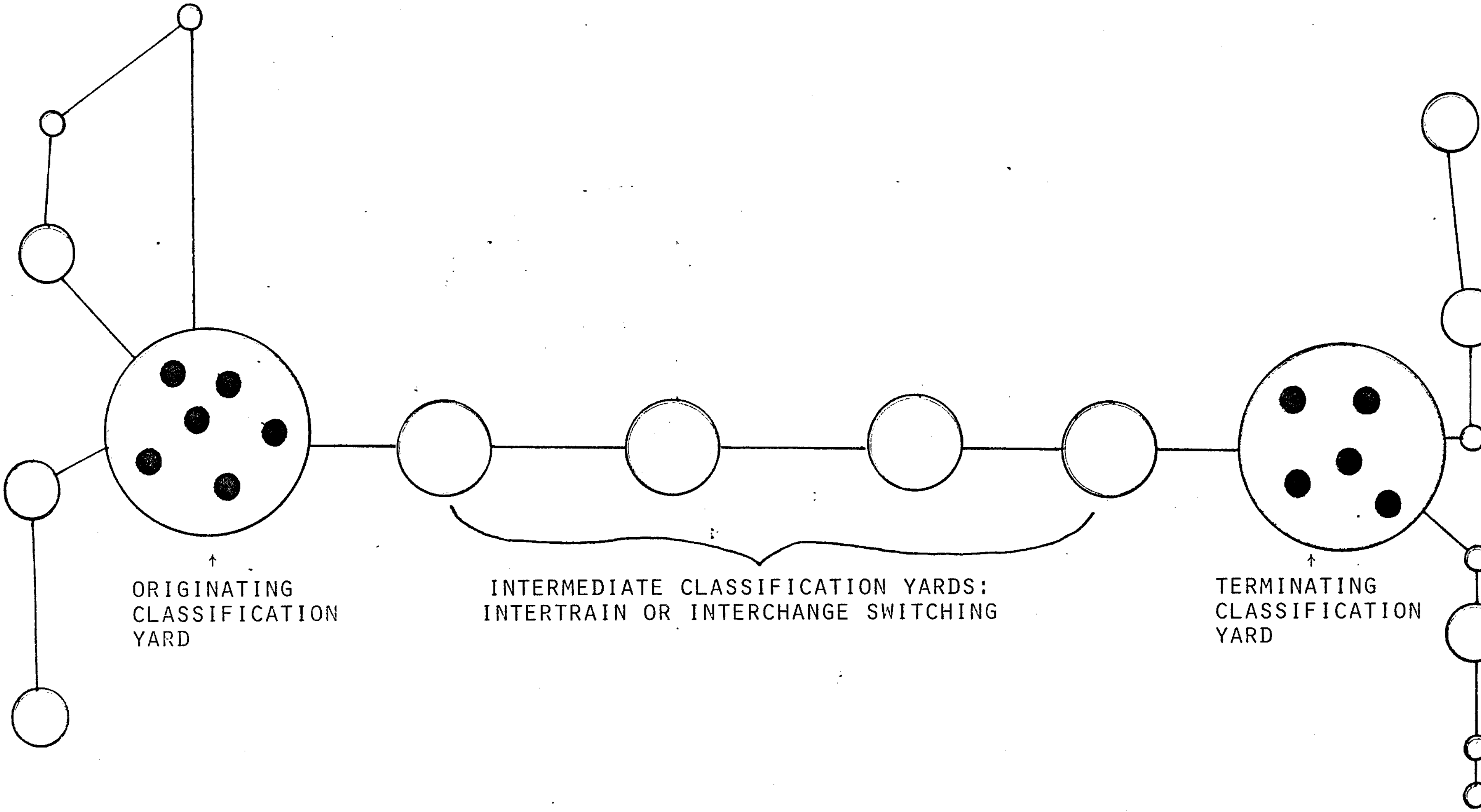
In the majority of instances, transportation managers will be concerned solely with the third stage of the process. Once the Worktable E files have been compiled, computerized costing programs are available (as will be detailed later) which will automatically retrieve the necessary variables from the Phase II data base and perform certain types of cost calculation. Before describing the computer algorithms, however, the paper will turn to the topic of costing methodology and present a brief overview of some of the concepts behind the programs.

4.2.1 Conceptualizing Railroad Services

Railroad operations, in the abstract, may be thought of as the provision of services over a physical network which has several dimensions. Exhibit 3 depicts an abstract rail network consisting of a series of links and nodes. While on a given link, a shipment is being transported in a road train which is moving from one node to another within the network. While at a node, the shipment is receiving some sort processing, such as classification, switching, or loading/unloading.

Exhibit 3

RAILROAD OPERATING ABSTRACT



LEGEND:
- ◯ INDUSTRY YARDS
- ○ INDUSTRY SIDINGS, OUTSIDE SWITCHING LIMITS
- ● INDUSTRY SIDINGS, WITHIN SWITCHING LIMITS

The nodes consist of two types: (1) industry yards or sidings and (2) railroad classification yards.[10] Industrial yards or sidings may be located either within the switching limits of classification yards, in which case no road train service is required during the gathering or delivering phases of the shipment, or outside of the switching district in which case road train service is required.

During the course of a movement, a consignment may avail itself of several classification yards enroute. Of these, two are of primary significance: the originating classification yard (that yard which serves the consignor and which initially sorts and classifies the shipment) and the terminating or destination classification yard (where the consignment is broken out of the last road train, classified and made ready for delivery to the consignee). The shipment, in addition, may pass through other intermediate yards between the originating and terminating railroad yards where the consignment is repositioned within a train (intratrain switching), switched from one train to another on the lines of the same carrier (intertrain switching), or interchanged between carriers.

Not all shipments or classes of service avail themselves of railroad classification services or entail the same road train service as others. The basic objective of cost analysis is to identify the expense associated with each class of service. Many of the differences between the various service levels which can be offered by railroads were discussed earlier, in general terms. By way of synopsis, the requirements of each service level in terms of railroad facilities and activities are presented in Exhibit 4.

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[10] While technically the same, the term industry yard is used here to denote facilities serving multiple shippers as opposed to sidings which implies facilities at an individual shipper's location.

Exhibit 4

A Synopsis of Service Level Differences

SINGLE-CAR

1. May require way train handling
2. Originating yard classification required
3. Intermediate yard classification normally required
4. Destination yard classification required
5. Routing may be circuitous (not the most direct route)
6. Small cutsize - normally less than 5 cars

MULTIPLE-CAR

1. May require way train handling
2. Originating yard classification required
3. Intermediate yard classification normally required, but at a reduced rate
4. Destination yard classification required
5. Larger cutsize, particularly for single-origin shipments

UNIT TRAIN

1. No way train handling required
2. No yard classification required
3. Direct routing (no circuity)
4. Train returns empty for reloading to the same station

TRAINLOAD

1. No way train handling required
2. No yard classification required
3. Direct routing on the loaded portion of the movement
4. The train does not necessarily return empty to origin for reloading

V. Computer Costing Algorithms

Prior to the development and release of Phase III of URCS by the ICC, transportation analysts were required to either write their own shipment costing programs or manually calculate costs from Rail Form A unit costs and operating factors. Manual calculations, while still possible, have become considerably less feasible since the development of URCS. The 1980 version of the Railroad Cost Scales sometimes requires the computation of values in several different tables, with the entire process being time-consuming and perhaps confusing to those persons unfamiliar with cost analysis. There are shipment costing packages available, however, which will automatically retrieve the data inputs (from Worktable E), calculate costs, and generate detailed movement reports. Two such mainframe algorithms are discussed below.

5.1 Mainframe Costing Algorithms

Phase III, developed by the Bureau of Accounts, will calculate shipment costs and service level costs to a certain degree. Phase III, while functioning separately from Phase II, still requires the presence of Phase II before it can operate. The USDA shipment costing program for agricultural and bulk commodity movements, developed by the Upper Great Plains Transportation Institute (UGPTI), performs the same or similar functions as Phase III. The USDA program essentially builds upon the methodology and structure of Phase III.

Unlike Phase III the USDA/UGPTI program is completely separate from and does not require an in-house version of Phase II. The program comes complete with its own data library which contains specially formatted versions of regional Worktable E records, and features a data base management system which supervises the manipulation and update of the input and output files. The USDA model functions conversationally as a completely menu-driven program and entails the capability to automatically adjust certain of the regional Worktable E operating factors (principally, all road train performance factors) if an analyst so desires.

Methodologically, the USDA/UGPTI algorithm goes a few steps beyond URCS in the calculation of shipment costs. The USDA/UGPTI version specifically allows the approximation of trainload and/or multiple origin costs, which Phase III does not, and utilizes more precise engine switching adjustments.[11] These enhancements are invoked, however, only at the request of the analyst. The algorithm essentially entails two program branches, the first which follows the Phase III methodology verbatum; the second which incorporates the methodological aspects noted above. The analyst thus has the option of using either of the two procedures. The Phase III methodology may be preferred for example in regulatory proceedings while the UGPTI methodology may be desired the purposes of distribution analysis, rate negotiation or state rail planning.

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[11]Phase III and methodology option one of the USDA costing system employ locomotive switching adjustments taken from Ex Parte No. 270 (Sub No. 4). These factors call for a 50 percent reduction in switching minutes per carload for multiple-car shipments and a 75 percent reduction for unit train/trainload consignments. In lieu of the Ex Parte 270 adjustments, program option two uses a sliding scale of adjustment factors taken from "Improved Regulatory Costing Methodology for Railroads". This adjustment scale, which has been used by the ICC in revenue burden studies in the past, provides for different adjustments over a range of different carload block sizes. The scale recognizes that the switching efficiencies for a 10-car block will not likely be as great, on a per-car basis, as the efficiencies gained in switching 40 cars. These adjustments may be found in "Notice of Proposed Rulemaking, Rail Market Dominance and Related Considerations," Federal Register Volume 45, No. 12, Thursday, January 17, 1980.

Exhibit 5 depicts the flow of a USDA costing session from beginning to end. As the graphic depicts, analysts are allowed to input the minimal or required parameters from a remote terminal, and optionally modify a broad range of default parameters. The program then automatically verifies the inputs, calculates the costs, and develops screen displays and/or reports of the shipment analysis. The process, as indicated, is cyclical in nature, with the analyst possessing the option of costing additional movements or terminating the session.

5.2 Line Segment Costing Model

The UGPTI has developed a separate line segment costing model which will estimate on-branch and off-branch rail costs. The model is currently being incorporated into the mainframe costing package and will be available as a program option when the reprogramming is complete. This expanded mainframe version is schedule for completion by July of 1985 at the latest.

5.3 Micro-Processor Program

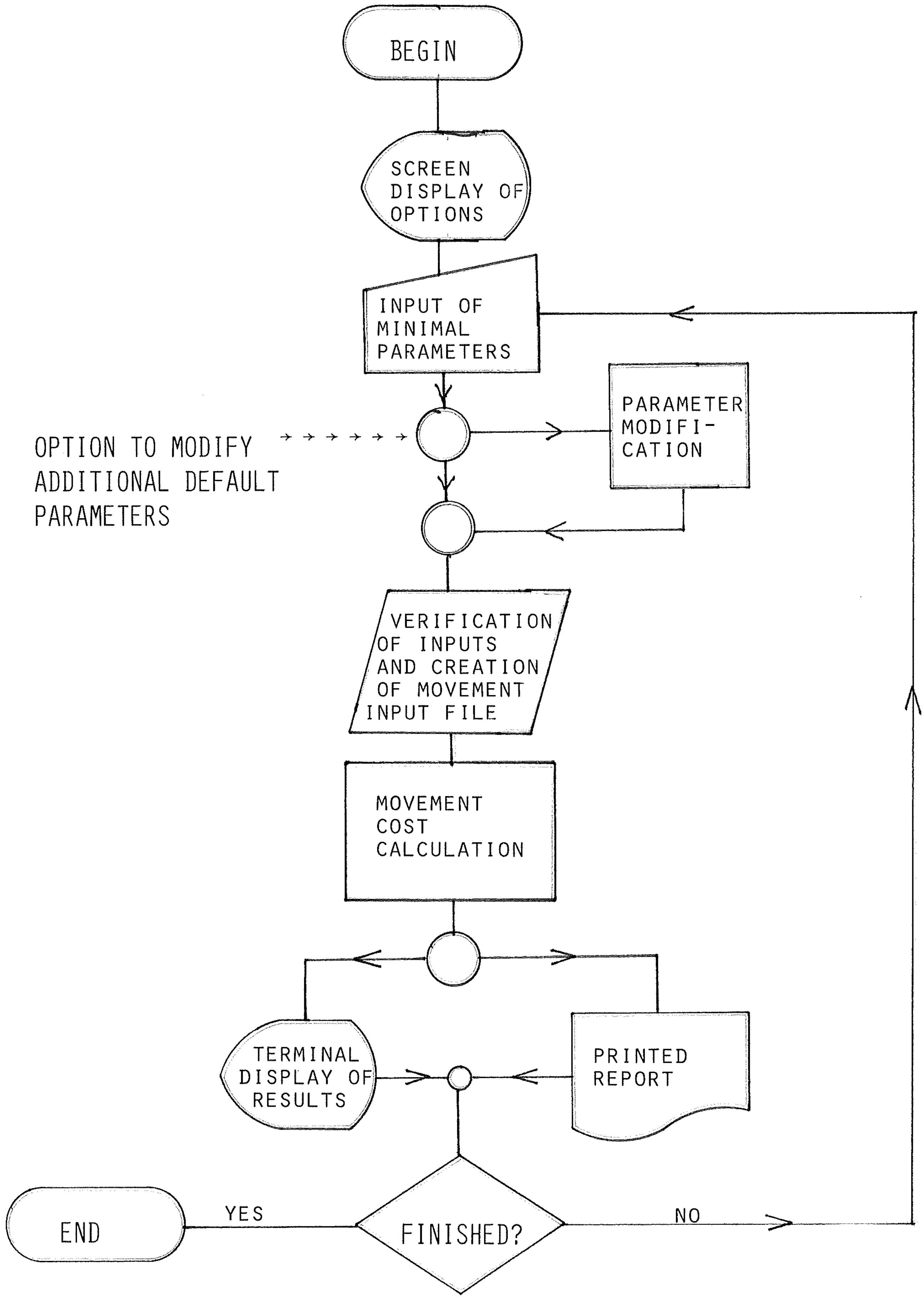
The UGPTI is currently engaged in the translation of the mainframe algorithm into a micro-computer package. The translation, which is currently under way, will make available all of the mainframe options and methodological branches to micro-computer uses. The program is being designed for the IBM PC but should be compatible with a range of other machines. The micro-computer version, including a line-segment option, is scheduled for completion by August of 1985.

VI. Conclusion

This paper has overviewed some of the principal uses of rail cost data within the contexts of transportation management, government

Exhibit 5

FLOW OF TERMINAL SESSION



regulation and planning, and policy analysis. The paper has overviewed the cost-finding process and highlighted the capabilities of existing mainframe computer algorithms. The paper, in addition, has pointed out the on-going enhancement of the UGPTI version, which is currently underway, and the design and programming of a micro-computer version, which will be available in the summer of 1985.

Appendices A and B provide more detailed information concerning certain items which were discussed in the text of the paper.

Appendix A

Overview of Phase I Cost-Out Relationships

The purpose of this appendix is to present some of the major cost-output relationships identified by the ICC in their preliminary 1980 cost study. The intent is only to exemplify the types of models which are developed and further familiarize transportation analysts with the principal account and output items under consideration, not to paint a full-blown picture of the statistical study.

In hypothesizing cost models, a generic function of the following type may be thought to characterize most railroad relationships.

$$C = f(K, Q_1, Q_2 \ldots Q_n)$$

where: C = railroad cost

K = a capacity variable such as miles of road, which may or may not be included in a particular model

Q = a vector of output measures such as gross ton miles, car miles, locomotive miles, etc.

Exhibit A.1 depicts some of the major expense clusters utilized by the ICC, and the output measure(s) which were associated with the account groups. The exhibit, in addition, overviews some of the principal expense items in each acocunt cluster.

Exhibit A.1

MAJOR EXPENSE AND OUTPUT RELATIONSHIPS

I. RUNNING TRACK MAINTENANCE

A. PRINCIPAL EXPENSE ITEMS

1. RAIL, TIES, BALLAST, & OTHER TRACK MATERIAL
2. ROADWAY
3. BRIDGES AND TRESTLES
4. TRACK LAYING AND SURFACING
5. SIGNALS & INTERLOCKERS AND GRADE CROSSINGS

B. OUTPUT MEASURE -- GROSS TON MILE

II. TRACK MAINTENANCE OVERHEAD, OTHER EQUIPMENT MAINTENANCE AN OVERHEAD

A. PRINCIPAL EXPENSE ITEMS

1. ADMINISTRATION / SUPERINTENDENCE
2. SHOP BUILDINGS AND OTHER ROADWAY STRUCTURES
3. ROADWAY MACHINES, SMALL TOOLS AND SUPPLIES
4. SNOW REMOVAL
5. JOINT FACILITY EXPENSES

B. OUTPUT MEASURES:

1. MILES OF ROAD
2. GROSS TON MILES

III. CREW WAGES-RUNNING

A. ENGINE AND TRAIN CREW WAGES

B. OUTPUT MEASURES

1. MILES OF ROAD
2. TRAIN HOURS, WAY SWITCHING
3. TRAIN MILES

IV. FUEL-RUNNING

OUTPUT MEASURES

1. GROSS TON MILES
2. LOCOMOTIVE UNIT MILES
3. TRAIN HOURS, WAY SWITCHING

V. ROAD LOCOMOTIVE SERVICE, REPAIRS AND OVERHEAD

OUTPUT MEASURES

1. MILES OF ROAD
2. GROSS TON MILES
3. LOCOMOTIVE UNIT MILES
4. TRAIN HOURS, WAY SWITCHING

VI. MAINTENANCE OF SWITCHING TRACKS AND SWITCHING OVERHEAD

A. PRINCIPAL EXPENSE ITEM

1. RAIL, TIES, BALLAST, OTHER TRACK MATERIAL
2. ROADWAY, BRIDGES AND TRESTLES
3. SIGNALS, INTERLOCKERS, AND GRADE CROSSINGS
4. JOINT FACILITY EXPENSES

B. OUTPUT MEASURES -- TRAIN HOURS, YARD AND WAY SWITCHING

VII. YARD OPERATIONS

A. PRINCIPAL EXPENSE ITEMS

1. LOCOMOTIVE FUEL AND YARD ELECTRIC POWER
2. YARD AND TERMINAL CLERICAL
3. SWITCHES AND SIGNALS
4. LOCOMOTIVE SERVICING
5. CONTROLLING OPERATIONS
6. ADMINISTRATION

B. OUTPUT MEASURES -- YARD SWITCHING HOURS

VIII. SWITCHING CREW WAGES

OUTPUT MEASURES

1. TRAIN HOURS
2. YARD SWITCHING

IX. YARD LOCOMOTIVE REPAIRS

OUTPUT MEASURES

1. MILES OF YARD SWITCHING TRACK
2. YARD SWITCHING HOURS

X. FREIGHT CAR REPAIRS

OUTPUT MEASURE

CAR MILES, RAILROAD OWNED OR LEASED EQUIPMENT

XI. FREIGHT CAR REPAIRS -- OVERHEAD

A. PRINCIPAL EXPENSE ITEMS

1. SHOP BUILDINGS
2. EQUIPMENT DAMAGE, DISMANTLING OR RETIREMENT
3. ADMINISTRATION

B. OUTPUT MEASURES

1. MILES OF RUNNING TRACK
2. CAR MILES

XII. GENERAL ADMINISTRATION AND OVERHEAD

A. PRINCIPAL EXPENSE ITEMS

1. COMMUNICATION SYSTEMS, COMPUTERS AND EDP EQUIPMENT
2. STATIONS AND OFFICES
3. LOSS AND DAMAGE CLAIMS PROCESSING
4. ACCOUNTING, FINANCE, AND CLERICAL
5. MARKETING, SALES, INDUSTRIAL DEVELOPMENT
6. PUBLIC RELATIONS
7. RESEARCH AND DEVELOPMENT

B. OUTPUT MEASURES

1. MILES OF RUNNING TRACK
2. GROSS TON MILES

Appendix B

Derivation of Variable Unit Costs in Phase II of URCS

The purpose of the appendix is to more fully explain the process whereby the variable unit costs are calculated within Phase II of URCS. In an effort to illustrate the process, Exhibit B.1 depicts a hypothetical calculation or cost assignment for a railroad based on some preliminary ICC regression results. In this example, a particular account or account cluster is distributed between the gross ton mile (GTM) and car mile (CM) output units. The regression coefficients from the Phase I study (.004 and .33 respectively) are used in step 3, in conjunction with the annual operating statistics for the carrier (500,000 gross ton miles and 5,000 car miles respectively) to derive cost variability ratios for the account. These ratios are then converted in steps 4 and 5 to variability percentages for each output measure using the assignment ratios or proportions developed in step 3. Once the annual variable percents have been developed for specific expense-output relationships, the account totals for the carrier are then converted to unit costs in Worktable D.

Exhibit B.2 depicts a sample Worktable D unit cost calculation. In this instance, the account which was analyzed (in Exhibit B.1) contains $6,000 for the current year. Bringing forward the data from Exhibit B.1, calculations 1 and 2 in Exhibit B.2 show the derivation of a unit cost per gross ton mile and car mile respectively.

Exhibit B.1

SAMPLE VARIABILITY AND COST ASSIGNMENT PROCESS WORKTABLE C

INPUTS

1. PHASE I REGRESSION EQUATION (WORKTABLE A5):

   ANNUAL EXPENSE = 1,000 + (.004 X GROSS TON MILES) + (.33 X CAR MILES)

2. ANNUALIZED STATISTICS (WORKTABLE A1):

   GROSS TON MILES = 500,000 CAR MILES = 5,000

CALCULATIONS

3. COST VARIABILITY - GROSS TON MILES:

   A. $GTM = \frac{(.004) \times (500,000)}{1,000 + (.004 \times 500,000) + (.33 \times 5,000)} = 0.430$

   B. $CM = \frac{.33 \times 5,000}{1,000 + (.004 \times 500,000) + (.33 \times 5,000)} = 0.355$

OUTPUTS

4. TOTAL PERCENT VARIABLE = 78.5%

5. ASSIGNMENT

   A. GTM = 0.430 ÷ 0.785 = 54.8%

   B. CM = 0.355 ÷ 0.785 = 45.2%

Exhibit B.2

SAMPLE UNIT COST CALCULATION IN WORKTABLE D

INPUTS

	ITEM	AMOUNT	SOURCE
1.	ANNUALIZED EXPENSE	$6,000	WORKTABLE A2
2.	PERCENT VARIABLE	78.5	WORKTABLE C1
3.	ASSIGNMENT PERCENT		
	(A) GROSS TON MILES	54.8	WORKTABLE C1
	(B) CAR MILES	45.2	WORKTABLE C1
4.	ANNUALIZED STATISTICS		
	(A) GROSS TON MILES	500,000	WORKTABLE A1
	(B) CAR MILES	5,000	WORKTABLE A1

CALCULATIONS

1. VARIABLE UNIT COST PER GROSS TON MILE =
   [($6,000) x (.785) x (.548)] ÷ 500,000 = $0.0052
2. VARIABLE UNIT COST PER CAR MILE =
   [($6,000) x (.785) x (.452)] ÷ 5,000 = $0.4258