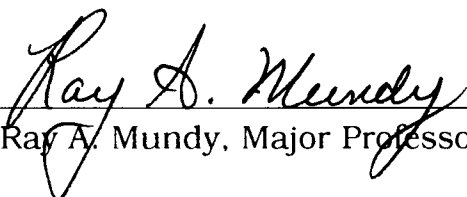
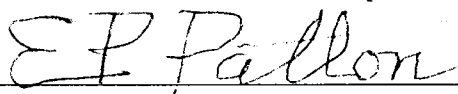
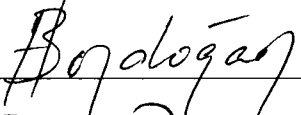
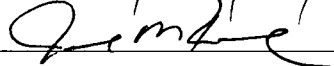


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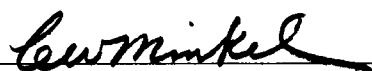
I am submitting herewith a dissertation written by Gregory M. Kellar entitled "Cost Allocation Pricing (CAP) in the Motor Carrier Industry." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Business Administration.


Ray A. Mundy, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:


Associate Vice Chancellor and
Dean of The Graduate School

COST ALLOCATION PRICING (CAP) IN THE MOTOR CARRIER INDUSTRY

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Gregory M. Kellar
August 1996

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Dedication

I dedicate this dissertation to Lisa, my wife, and to my children. To Lisa, whose unending support (both financial and emotional) has enabled me to complete this academic pursuit. She has encouraged when appropriate and has remained silent when my temperament demanded it. She is the real heroine behind this project. To my children for all they have put up with during the course of my arrival to this point, and the love they have never ceased to give.

.

Acknowledgments

The completion of this dissertation has seen the willing contribution and participation of many parties. In many ways, it has been a team effort. I hesitate to mention anyone for fear that I will omit and offend someone that has played an instrumental role. I hope that those not explicitly mentioned here will understand and accept my heart felt gratitude for their help, time, efforts, and energies in my behalf. My oversight at the time of this writing in no way diminishes the role that they played. This dissertation would not have arrived at this final destination without each and everyone's help.

I would like to mention some persons that played truly heroic roles in the completion of this project. A long meeting with Bill Dewitt, former executive for Burlington Motor Carriers and Burlington Northern Railroad, proved to be invaluable. The insights gathered from the meeting tremendously enhanced the project.

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LandAir Transport, Inc. contributed funding for this project. Additionally, several persons at LandAir Transport, Inc. spent an enormous

amount of time on this project and were pivotal to its success, namely, Jeff Woods, Vice President of Operations, John Tweed, Vice President of Marketing, Jeff Taylor, Cost and Software Support Analyst, and David Lloyd, Pricing Analyst.

Frank Davis, Jr., Ph.D. introduced me to this project and continued to offer support, encouragement, and a wealth of wisdom and insight throughout.

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Ray A. Mundy, Ph.D. promoted the research and gave it direction. He chaired the dissertation research committee. He played the role both of critic and defender as the occasions demanded. The professional manner in which he conducted himself, his constant example, and his technical advice continued the project at critical crossroads.

Finally, Lisa Collier Kellar, M.D., my wife, deserves at least as much credit for the completion of this project as do I. She has played the roles of editor, sounding board, technical advisor, typist, type setter, and researcher. She has contributed through critical analyses that forced me to redirect focus or to clarify critical points throughout the process. Her undying encouragement and gentle persuasion caused the project to reach completion. Undoubtedly, this research would not have reached this point without her.

Abstract

Profitable price negotiation in the irregular route truckload motor carrier industry is difficult due to the complexity of the interrelationships among the many distinct geographic market segments and because of the several components or dimensions of price that must be properly harmonized. Concurrently, economic forces and competitive pressures are driving down profits, forcing management to become more concerned about understanding the multiple influencers of price. Further complicating the problem of profitable price negotiation is the dynamic nature of the industry. Decisions must be made quickly. There is little time for analyses. This forces decisions to be made with inadequate preparation. Decisions that often are determined, after the fact, to have been unprofitable and undesirable.

This research provides a solution to the problem of making dynamic pricing decisions with inadequate analyses or preparation in the irregular route truckload motor carrier industry. A dynamic pricing system is developed and operationalized through the creation of a software prototype. It suggests prices based upon market segment specific historical data, variable and fixed costs, competitive pressures, non-revenue activ-

ity, capital costs, tax costs, variation in historical data, and corporate objectives. It further provides information regarding the profitability of linked market segments so that profitable pricing can be balanced when necessary.

All analyses are done in real time using real-time data. The software typically takes less than five seconds to provide management with the information mentioned above.

The value of the dynamic pricing decision support tool to industry was measured by placing the software prototype on-site with industry partners. The tool was found to enhance the decision making process. It also changed management's perception of the profitability of selected, existing market segments currently being served.

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Part I

Problem Statement

Introduction

"[H]umans can forget relevant factors, especially if under stress or in a situation where time is critical...."

"Most experts will freely admit to having gaps in their knowledge..."¹

Today's rapidly changing business environment demands more of management than ever before. Recent corporate downsizing exacerbates this problem, as more decisions must be made by fewer individuals. These decisions require an in-depth knowledge of customers and their individual needs and behaviors. However, few individuals can easily recognize or consistently remember all relevant information, particularly when making decisions under pressure.²

Many firms currently collect electronic data that could provide the facts that are needed to assist in decision making, but the data are often not organized properly, making the information nearly inaccessible. This means that important information, including business trends, often remains concealed in the data, and management judgement does not benefit from the potential information at hand.³

1. Basden, Andrew, "On the Application of Expert Systems," *Developments in Expert Systems*, Academic Press, London, 1984, pp. 64, 66, as quoted in: Allen, Mary Kathryn, *The Development of an Artificial Intelligence System for Inventory Management*, A dissertation for The Ohio State University, Published by The Council of Logistics Management, 1986, p. 10.

2. Verity, John W. and Russell Mitchell, "A Trillion-Byte Weapon," *Business Week*, July 31, 1995, p. 80.

3. Verity and Russell, p. 20.

While enhanced and more rapid access to properly organized and more effectively and efficiently manipulated data would benefit decision making in any industry, this dissertation will deal specifically with pricing decisions in the truck load motor carrier (TLMC) industry. In particular, this research will develop and measure the benefits of a state-of-the-art pricing suggestion system for the TLMC industry. The system will be developed using well established concepts and theories found in the literature, as well as an understanding of current challenges and market pressures facing the industry, and will employ several current technologies such as *activity based costing* (ABC) and *economic value added* (EVA). In order to measure the benefits or value of the system, a GUI-based software prototype will be developed and placed on-site with industrial partner(s). This process of operationalizing the model will draw from technologies in several fields, including, among others, dynamic forecasting, information engineering, and information theoretic statistics (ITS).

The testing and evaluation of the operationalized system will accomplish the ultimate goal of this research, which is to measure both the economic and perceived value of a dynamic pricing suggestion system that is based on accurate, rapidly accessed, current data. It is hypothesized that because of its constantly changing environment, the TLMC industry could benefit greatly from such a dynamic pricing tool.

Background

TLMC Industry Today

TLMC's today face challenges that are difficult—if not impossible—to overcome with the management tools commonly available. Since the Motor Carrier Act of 1980 (reregulation), the number of regulated truck load (TL) carriers has grown tremendously.⁴ Excess capacity has existed almost constantly since 1980 among both irregular route and dedicated service TL carriers,⁵ allowing market forces to drive the industry.⁶ Shippers have enjoyed a position of negotiating strength throughout most of this period,⁷ and they can demand higher levels of service than in the past, frequently at reduced rates.⁸

4. Lieb, Robert, *Transportation*, DAME Publications, Inc., Houston, TX, 1994, pp. 84, 86, and 304.

This trend promises to increase as "it is the Federal transportation policy to...[s]upport repeal of remaining Federal laws imposing economic regulation on motor carriers." See: *Moving America: New Directions, New Opportunities*, U.S. Department of Transportation, Feb. 1990, p. 70.

5. "Special Report, Truckload Freight, Truckload chief says shift in Congress eliminates some worries, adds others," (interview with Lana R. Batts), *Traffic World*, (No. 5, Vol. 241, Whole No. 4578, Week of Jan. 30, 1995, pp. 27, 34.; and Tyworth, John E., Joseph L. Cavinato, and C. John Langley, *Traffic Management: Planning, Operations and Control*, Addison-Wesley Publishing Company, Reading, MA, 1987, p. 255.

6. Raue, Michael J., "You Can't Determine Prices Until You Understand Costs," *Transport Topics*, June 19, 1995, p. 17.

7. "Special Report," pp. 27, 34.

8. Mundy, Ray A., Brian J. Gibson, Gregory M. Kellar, and Edwin P. Patton, "Utilizing a Carrier Management Continuous Improvement Framework (CMCIF) Model and Activity Based Costing in the Management of Transportation Services", *Journal of Transportation Management*, accepted for publication Aug. 1994, pp. 3-5.

See also: Lieb, p. 236.

In this environment of existing excess capacity and low barriers to entry, the emergence of today's version of ruinous competition is a constant threat.⁹ In fact, as John D. Schultz has pointed out, evidence of this is seen in the growing concentration of carriers currently taking place in the TLMC industry as some businesses merge and others succumb to competitive market conditions.¹⁰ Those that survive have often seen profits drop dramatically and/or have been forced to scale down their operations and offerings.¹¹ Consequently, TL carriers are being forced into a reactive, rather than proactive management style as they try to adapt to a market where changes are frequent and often significant. Business survival in this environment is difficult, and attempting to flourish offers a seemingly impossible challenge.

Survival

An obvious question surfaces as to whether or not there is anything a firm can do to increase its chances of survival. Heuristics, philosophies and theories abound that suggest more profitable ways of running responsive organizations.¹² These vary from price discrimination to total quality management (TQM)

9. Locklin, Ph.D., D. Philip, *Economics of Transportation*, 1935, Richard D. Irwin, Inc., Chicago, IL, Revised Edition, W. B. Conkey Co., Hammond, IN, 1946, pp.149-150, 306-307; and Lieb, pp. 304-305.

10. Schultz, John D., "Con-Way expands truckload offerings, earmarks \$25 million for fleet additions," *Traffic World*, No. 4, Vol. 242, Whole No. 4590, Week of Apr. 24, 1995, p. 11; the use of the term "growing concentration" parallels its use by Lieb in his description of the LTL industry (see: Lieb, p. 304); see also: B. Starr McMullen and Hiroshi Tanaka, "Structural Differences Between Large and Small U.S. Motor Carriers Following Deregulation; Implications for Market Structure," *Pre-Meeting Proceedings, Transportation Research Forum 34th Annual Meeting*, Russell B. Capelle, Jr. (editor), TRF, St. Louis, MO, Oct. 21-23, 1992, section 2, McMullen pp. 1-2.

11. Lieb, pp. 304-305; For example: PST Vans is in reorganization (see: Bearth, Daniel P., "PST Vans: From Bankruptcy to IPO," *Transport Topics*, No. 3108, Feb. 27, 1995, p. 4); LTL examples include: Mason and Dixon, Spector Red Ball, Smith's of Staunton, McLean, etc. (see: Patton, Edwin P., *Motor Carrier Costing and Profit Analysis*, Class materials packet, Log/Trans 402, University of Tennessee, Knoxville, Fall 1990, pp. 1-2.).

to process reengineering. All these methods have their shortcomings and detractors, and still leave unanswered the question as to whether there is any way to avoid failure, particularly for medium-to-small firms that do not have extensive capital resources to fall back on.

Some firms appear to have found a solution to these problems and are not only surviving in today's environment, but are actually thriving. For example, Schneider Motor Carriers has been experiencing significant success recently. Don Schneider, CEO and president, attributes the company's success to its use of "Information Resources."¹³ He recently stated that his company was "not in the trucking business, but rather in the information business."¹⁴ While it is not clear how much of the success that this firm has experienced can actually be attributed to its information systems (since it has so many other resources that contribute to its success) it is significant that Don Schneider attributes their success foremost to information management, and views his company as being in the "information business."

In the TLMC industry, by basing management decisions on improved information, a more proactive management style is possible which should allow many firms to become increasingly more productive. In a time of consolidation, this ability to manage proactively and profitably could be the difference between survival or extinction. As figure 1 projects, in the pursuit of profits, superior information should convert unprofitable transactions to money-making transactions.

12. Davis, Jr., Frank and Karl Manrodt, "Service Logistics: an Introduction," *Annual Conference Proceedings, Council of Logistics Management, Fall Meeting*, Oct 7-10, 1990, Volume II, Anaheim, CA, pp. 67-92; and Mundy, et al., 1994, pp. 1-23.

13. Levinson, Marc, "Riding the Data Highway. (Schneider National Inc. Uses Sophisticated Technology to Manage its Fleet of Trucks)," *Newsweek*, March 21, 1994, Vol. 123, No. 12, p. 54.

14. Levinson, p. 54.

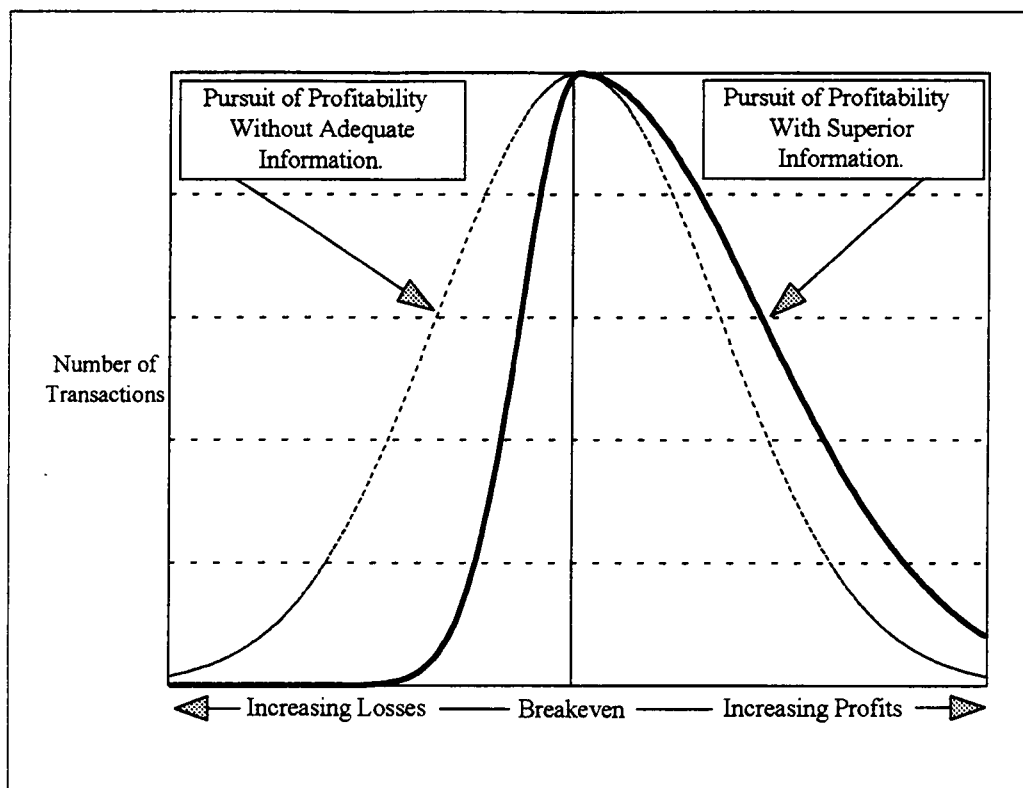


FIGURE 1 Influence of Information on Profitability

The figure shows two curves. The dashed curve resembles a normal distribution curve and indicates that transactions are about as likely to be profitable as unprofitable when profit determining decisions are made randomly, or with inadequate or incomplete knowledge or information. The solid curve indicates that a shift occurs, moving unprofitable transactions to profitability with the strategic and tactical use of superior information. This is a graphical representation of the phenomena that Schneider Motor Carriers has experienced.

Information and Data

Information has been defined as "data endowed with relevance and purpose."¹⁵ Managers today frequently have access to large amounts of data, and many technologies exist to facilitate its rapid acquisition, analysis, and use.¹⁶ These technologies include such tools as database management programs and spreadsheets. Such tools can quickly show relationships and trends in the data, thus providing details for decision making.

With the combination of the existing data and these data analysis tools, managers have an ideal opportunity to manage with increasing foresight and profitability. In an era hailed as the information age, this improved ability should provide managers with rapidly accessible, time-sensitive knowledge to make better decisions. In particular, pricing decisions should improve given the vast amount of customer, cost, and transaction data available.

Data not Exploited

Unfortunately, the ability to use data rapidly and effectively to support decisions is not as common as it should be. Although vast amounts of data are automatically collected electronically, the data are usually structured for accounting or transaction retrieval purposes, not for decision-support applications.¹⁷ A transformation of the data into useful information requires planning, data analysis and effort. As Peter F. Drucker noted: "Converting data into information

15. Drucker, Peter F., *The New Realities: In Government and Politics / In Economics and Business / In Society and World View*, Harper & Row, New York, NY, 1989, p. 215.

16. Preissler, Kenneth and Frank Davis, "Several Technologies such as RAD, JAD, etc.," presented at DNA Annual Conference, Boston, MA, Sept. 15, 1994.

17. Ernst & Whinney in collaboration with Cleveland Consulting Associates, *TRANSPORTATION ACCOUNTING & CONTROL: Guidelines for Distribution and Financial Management*, National Council of Physical Distribution Management and National Association of Accountants, Oak Brook, IL, 1983, p. 164.

requires knowledge.”¹⁸ Unfortunately, many firms do not take the necessary steps to take advantage of their automatically collected, electronic data. In fact, even over a decade ago Naisbitt observed, that many firms are “drowning in information, but starved for knowledge.”¹⁹

This under-utilization of automatically collected data is due in part to the significant corporate resources—such as capital required for hardware purchases and software development, and time commitment by management to refocus company policy and retrain personnel—that must be brought to bear before historical data can become useful. It is also due to what amount to, at times, a shortage of appropriate software, as will be discussed.

In short, platitudes about the “information age” and conventional wisdom regarding the benefits of electronic data collection and analyses all too often remain unrealized. This is particularly true of attempts to use the data tactically. For example, the dynamic use of computer data to assist real-time pricing decision making is rare in computer based decision-support tools, particularly in the TLMC industry.^{20, 21} Indeed, since data analysis is relatively slow, when data is used to aid decision making, management’s use of the data is often limited to strategic (long-term), rather than tactical situations.

18. Drucker, p. 215.

19. Naisbitt, John, *Megatrends: Ten New Directions Transforming Our Lives*, Warner Books, Inc., New York, NY 1982, p. 24.

This has been reiterated more recently in: Raue, p. 17–18.

20. Raue, p. 18.

Pricing Information

Industry Need for Dynamic Pricing Decision Support

As mentioned previously, cost measurement devices and pricing suggestion systems are a class of decision-support tools that have received inadequate attention up to this point in the TLMC industry in spite of the potential benefits.²² The noticeable scarcity of pricing decision-support tools in the TLMC industry is surprising since few decisions influence corporate profitability as much as pricing decisions. In fact, since these decisions influence the marketing-mix by identifying target markets, which in turn affects sales volume, pricing has been "rated as the number one problem facing marketing executives."²³ Thus, the development of a dynamic pricing decision-support tool (DPDST), uti-

21. An extensive review of software as found in: Richard C. Haverly, Robert A. Weisstuch, and Jeffery S. Berkoff of Andersen Consulting for the Council of Logistics Management, *Logistics Software—1993 Edition*, CLM, 1993, does not reveal any dynamic pricing or pricing suggestion systems, and shows very limited costing or pricing software of any type commercially available. Further, while software, such as Rail Form A computer Costing Model and URCS, are available from the ICC, this software uses extensive averages, resulting in limited utility. I have further explored this subject with Kenneth Preissler (of Central Transport's MIS division); with John Kent (formerly of the MIS division of Burlington Motor Carriers and other carriers, and currently an intern with HighwayMaster Software); with Bill DeWitt (formerly of the board of Burlington Motor Carriers); with Jeff Woods (VP of Operations for LandAir Transport, Inc.); with John Tweed (VP of Marketing for LandAir Transport, Inc.); and with Jeff Taylor (Operations Cost Analyst for LandAir Transport, Inc.), all of whom state that dynamic pricing systems are not commonly embedded in software systems used in the TL motor carrier industry, and further confirm the general lack of available pricing software and the limited utility of what is available. Dynamic pricing decision-support software is not currently embedded in "HighwayMaster" (MIS software for the motor carrier industry). LandAir Transport, Inc. has used McCormick Software designed for an IBM AS400 system which does not include such a tool. A review of the documentation of Innovative Transportation System's Traffic Analyzer shows that this also lacks any dynamic pricing ability.

22. Allen, Mary K., *The Development of an Artificial Intelligence System*, Dissertation, The Ohio State University, 1986, p. 180.

23. See: "Segmentation Strategies Create New Pressure among Marketers," *Marketing News*, March 28, 1986, p. 1, as quoted in Kotler, Philip, *Marketing Management: Analysis, Planning, Implementation, and Control*, Prentice Hall, Englewood Cliffs, 1988, p. 495.

See also: Kotler, pp. 71-76 and 494-501.

lizing automatically collected data to aid pricing decisions, should have a tremendous value, both economic and perceived, to the TLMC industry.

While any business unit could benefit from an automated, dynamic decision-support tool to aid in suggesting and setting prices, it is more beneficial for some industries than others. Products or service offerings that have constantly changing costs, demand, elasticity, or competitive influences, have a greater need for a DPDST than those that enjoy great stability. The TLMC industry provides a prime example of such an industry since it experiences extreme levels of competition and a constantly changing operating environment (both political and economic.)

Pricing in the TLMC Industry

The irregular route TLMC industry experiences sufficient volatility (i.e., daily shifts in demand and cost patterns) to more than justify the creation and implementation of an automatic and dynamic pricing suggestion system. For instance, the volume of business in a given market segment often shifts daily as a result of the acceptance of new business or the discontinuation of existing service offerings. Other examples of business patterns that may change over time include fuel prices and fuel efficiencies of power units in different seasons of the year. As these and other attributes of a given market change, they should be recognized and factored into current prices.²⁴

One type of information that has the potential to significantly help any firm to avoid unprofitable pricing is an accurate knowledge and understanding of the costs of its activities and service offerings.²⁵ Because of the current lack of ade-

24. For a more in-depth discussion of how seemingly minor factors can influence profit margin significantly, see page 25.

25. Mundy, et al., 1994, pp. 9-10.

quate cost measurement devices, few TL firms enjoy a complete, much less accurate, comprehension of their costs.²⁶ Many costing systems still make extensive use of business averages,²⁷ are ad-hoc in nature and require significant attention and resources. When costs are finally calculated they are frequently inaccurate because they suffer from the use of aggregated and untimely data. These inaccuracies are due, in part, to ongoing changes in business patterns, compounded by the passage of time.

To avoid these errors, an ideal costing/pricing system should use disaggregated, on-line data to provide real-time, nearly instantaneous, measurements of costs. This disaggregation should be statistically optimized, balancing the competing forces of 1) decreasing relevance due to decreasing sample size (as data becomes more finely disaggregated, and 2) decreasing relevance due to the overuse of averages. This time-sensitive environment should provide superior information to management when compared to the current state of the art. The improved ability to accurately measure and use costs to assist the establishment of prices should help a firm to make better decisions and could ultimately improve profitability.

The suggestion of optimized prices based on accurate, current business transactions should provide a competitive advantage for any TLMC. The degree

26. Raue, p. 19.

See also: Beard, Robert, "Trucking Cost Analysis, a Panel Discussion," Bob Hasek, Organizer and Moderator, *Proceedings of the Transportation Research Forum*, TRF, Arlington, VA, Vol. 6, 1992, p. 268; Porter, Michael E., *Competitive Advantage; Creating and Sustaining Superior Performance*, The Free Press, New York, NY, 1985, p. 63.

27. Costing systems hailed as useful as late as 1993 advocated the use of aggregated and averaged data in costing measurements (see: Buxton, Freeman K. and Paul Bertels, "Estimating Refrigerated Motor Carrier Costs," *The Journal of the Transportation Research Forum*, V. 33, #2, Arlington, VA, 1993, pp. 26-32).

of competitive advantage should be increased if these pricing suggestions can be made in real-time.

Pricing Decision-Support Tools

Definition of Price

The development of a dynamic pricing suggestion system through the use of a DPDST requires a consistent definition of the term price. The use of the classical definition: a measure of the value of a product or service,²⁸ greatly simplifies this development. Notice that this definition should be distinguished from the common use of the term, which refers to the amount of an offer. For example, if a service is offered for \$500, but no one purchases the service, the value of the service at the offered place and time with the existing knowledge base must be less than \$500 to potential purchasers since it was not sold. Thus the \$500 offer would not constitute a price. The price or economic value of a product or service must be determined or set by both purchaser and seller. This will be discussed in somewhat more detail in part II.

Multiple Dimensions of Price

Of course, measuring the economic value of a product or service is a complex task because "price" spans several dimensions. Cost, demand/elasticity, customers, value of service, competition, markets, and corporate strategy are some examples of the dimensions of price. In order to most profitably establish prices, all influences should be taken into consideration. Detailed costs should

28. Marshall, Alfred, *Principles of Economics: An Introductory Volume*, Eighth Edition, MacMillan & Co. Ltd., London, Eighth Edition 1920, reprinted 1961, p. 51.

See also: Marx, Karl, *Capital: A Critique of Political Economy*, Frederick Engels (editor), The Modern Library, 1906, pp. 106-111.

be measured, demand/elasticity should be estimated, and customers' perception of the value of service should be considered.²⁹ Competitive influences should be combined with these analyses, target markets should be identified, and all factors should be evaluated in light of corporate strategy.³⁰

However, because of the wide scope and the numerous calculations required, the analyses mentioned are so time consuming that the effort and expense required to perform these calculations force many prices to be established without an appropriate amount of investigation.³¹ This failure to properly and dynamically estimate the economic value of an offering is unnecessary since the technology and theoretical understanding exist that could help industries develop automated pricing suggestion systems to perform these analyses rapidly and accurately.

Decision-Support Versus Decision-Making Tool

The decision-support tool proposed by this research should be contrasted with a decision-making tool. A decision-making tool automatically makes a decision whereas a decision-support tool functions in an advisory capacity only. An example of a decision-making tool can be found in the U.S. airline industry, another industry with service offerings that experience frequent changes in demand and competitive influences. To combat this volatility, airlines have been applying yield management for over a decade with the aid of a revenue management and reservation system that has cost about \$10 million per year.³² Only firms with revenues as large as some major airlines could afford to develop a

29. Kotler, p. 525.

30. Kotler, p. 496.

31. Kotler, p. 526. Kotler suggests preparing preplanned response to competitive price changes for "swift reaction." This implies that normally, the establishment of prices is too time consuming to allow for "swift reaction".

pricing system of this magnitude.³³ In spite of the apparent benefits that an automated pricing system (decision-making tool) brings to a firm, few firms have the resources to develop such a tool. Fortunately, technologies now exist that make possible the development of an affordable pricing decision-support tool. Besides the fact that a decision-support tool can be much less expensive to develop than a decision-making tool, many businesses might actually prefer a tool that *aids* management rather than trusting important managerial functions to an automated tool that *makes* decisions. Such decision-support tools are abundant in other applications. For example, Wall Street investors use many analysis tools (decision-support tools) on a daily basis, but combine these analyses with human judgement to make investment decisions. Similarly, in the TLMC industry, a tool that enhances management's understanding of prices and aids in decision making could greatly improve profitability by facilitating faster and more profitable pricing decisions.

Adequacy of Currently Collected Data for a DPDST

Many firms, even small and medium sized ones, automatically collect electronic transaction data. Often, these data could serve as a basis for an automated pricing suggestion system without great capital outlay, since the automatically collected transaction data could be analyzed to reveal estimates of demand and elasticity as well as play an integral role in cost determination. For

32. Burger, Todd (Organizer & Moderator), "Yield Management in the Rail Industry," *Proceedings of the Transportation Research Forum, Volume 6, 1992*, 34th TRF Annual Forum, St. Louis, Missouri, October 21-23, 1992, p. 324.

See also: Reed, Dan, *The American Eagle, The Ascent of Bob Crandall and American Airlines*, St. Martin's Press, New York, NY, 1993, pp. 182-184.

33. Major american airlines have revenues of at least 1 billion dollars annually. See: Reed, p. 270.

example, many TLMC's automatically measure and collect the number of revenue generating linehaul miles involved in each transaction. These measurements could then aid cost measurements (one of the above listed factors that influences price). In fact, the only elements necessary for price determination that cannot be estimated easily from commonly collected data are corporate strategy and competitive influences.

Additionally, the use of automatically collected transaction data endows the creation of pricing suggestion systems with the correct interplay between cost and price. This interplay is both obvious and subtle. On the one hand, prices should not be set below variable costs,³⁴ while on the other hand, common costs are partially determined by price since price influences sales volume, which in turn determines measured common costs on a per unit basis.³⁵ By using dynamic data, changes in business volumes can be detected immediately and used to update cost measurements so that price and cost measurements are always consistent. This issue will be dealt with in greater detail in parts II and III.

Characteristics of an Ideal DPDST

Market Segment Specific

A DPDST that addresses the dynamic environment in the TLMC industry should have several characteristics. Among others, it should allow prices to be market segment or even customer specific. Therefore, it should use statistically disaggregated data. The degree to which the historical data should be disaggre-

34. Maurice, S. Charles and Charles W. Smithson, *Managerial Economics, Applied Microeconomics for Decision Making*, Third Edition, Irwin, Homewood, IL, 1988, pp. 270-284.

35. Locklin, pp. 164-165.

gated should correspond to market segment definitions. As attributes of a given market segment change, the system should recognize and factor these changes into current prices. Ideally, a pricing suggestion system would be able to adapt to such changes quickly and automatically. This becomes complicated as market segments appear and disappear dynamically. However, in the past few years, statistical tools, such as neural networks, have been developed that will allow these dynamic analyses to take place.

Adaptable to Management Strategy

Another characteristic of an ideal DPDST would be the ability to adjust readily to changes in management strategy. For example, if a firm changed pricing strategies from markup pricing to target return pricing, the pricing suggestion system should be easily adapted from the old to the new strategy. This will assure that development efforts and costs are preserved as changes occur. It would be unwise and unnecessary to develop a DPDST that supports only a fixed pricing method for all transactions.

Rapidly Available Information

A significant benefit that a DPDST should bring to industry would be an increased speed with which effective decisions could be made. In order to realize this benefit, the tool must be easy to use. Otherwise, the potential benefit of increased speed in decision making might be negated by the difficulty of using the system. Ideally, the system would be electronically programmed into a user-friendly computer software package such as is commonly found in today's graphical user interface (GUI) computer software. The operational prototype that this research will develop will pursue this ideal.

Requirements for Development

In order to develop and implement a pricing tool that fully achieves the hoped for benefits, several things must happen. First, businesses and business managers must gain a vision of the full potential offered by the massive amount of data that is currently automatically collected. Second, managers must understand the limitations imposed by the present structure of this data. Third, algorithms and theories must be developed that better address management's needs and more fully take advantage of advancing technologies. Fourth, a change must occur that allows data to be collected, organized, and analyzed with real-time decision making as their primary objective.

These four points could be considered stages in the development of a fully functional, dynamic decision-support tool. This research will attempt to implement a stage three prototype for the tests mentioned earlier.

Currently Available Technologies

Technologies have been in existence for several years, such as information engineering³⁶ and a probabilistic neural network known as information theoretic statistics,³⁷ that could dramatically improve decision making if properly implemented.³⁸ These technologies allow large numbers of combinatorial options (thousands or millions of distinct mathematical models of current or potential business scenarios) to be compared in real time. The comparisons of these distinct mathematical models can then be linearly ordered to reveal busi-

36. See for example: Martin, James and Clive Finkelstein, *Information Engineering*, Savant Institute, London, UK, 1979, 2 vols., and other earlier works.

37. See: Akaike, H., "Information Theory and an Extension of the Maximum Likelihood Principle," *Second International Symposium on Information Theory*, B. N. Petrove and F. Csaki (editors), Akademiai Kiado, Budapest, 1973, pp. 267-281.

38. These and other relevant technologies are discussed in part II.

ness patterns that are hidden in automatically collected data—such as purchasing practices of certain customers, or seasonal demand shifts for various products or service offerings in various regions or market segments. The revelation of these hidden patterns should allow management to pursue optimal tactics and cost effective strategies that lead to greater profitability, particularly by facilitating the creation of near optimal prices on a market segment by market segment or a customer specific basis. Thus, a DPDST could make use of the above mentioned technologies to assist in the determination of prices.

The development of a strategic or tactical DPDST that incorporates all of the qualities and technologies that have been suggested could make a significant contribution to current pricing practice. It would advance several bodies of knowledge including those of pricing and of real-time data analysis³⁹ and would require several types of research, including statistical survey, applied, project, and process research.⁴⁰

Objectives of Research

This research will attempt to answer directly the research questions stated in the following sections. Furthermore, this research will provide, indirectly, an example of how real-time data can be used in decision-support applications to provide an advantage to management. The research will measure both the perceived value of the model to management as well as the economic value it provides. This sequence is shown in figure 2.

39. Raue, p. 19.

40. Lord Rothschild, "Forty-five Varieties of Research (and Development)," *Nature*, Vol. 239, 13 October 1972, pp. 373–378.

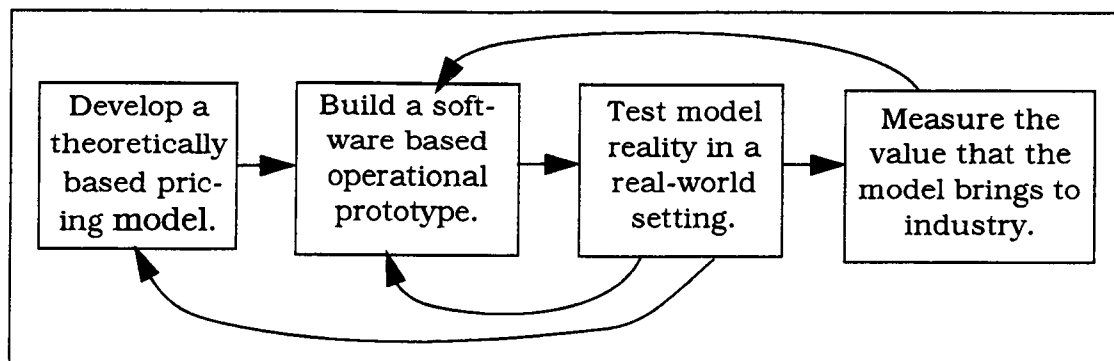


FIGURE 2 Research Stages

DPDST Development

The first set of research questions are associated with the development of the pricing system and can be summarized as follows:

1. How can currently available technologies not commonly utilized in pricing in the TL industry be harmoniously incorporated into a state-of-the-art pricing suggestion system?
2. What is the pricing system that this research will construct and suggest to advance the current state-of-the-art?

The first question will be answered in part by a literature review of the current state of the art in pricing, particularly as it applies to the TL industry, as well as a review of some of the technologies available that could further the development of both an improved pricing system and its operationalization. The answer to the first question will be completed and the second question will be answered by developing and giving a detailed description of the pricing system proposed.

The proposed system will operationalize and expand several concepts put forth over a decade ago.⁴¹ In particular, it will use automatically and naturally collected data to assist in identifying traffic or geographic market segments that should receive greater attention. This information can be used to identify geo-

graphic market segments that are unprofitable and should be abandoned. The system will incorporate several technologies not commonly used in pricing which will allow dynamic decision-support seldom found in pricing models. These technologies will be discussed in detail in part II. A brief explanation of the key attributes of the DPDST that will be developed as well as the roles of a few of the incorporated technologies follows.

Market Segment Identification

As mentioned, an important part of the proposed pricing suggestion model will be the dynamic and precise statistical identification of geographic market segments to facilitate cost allocation and hence pricing. This will be important since unique market segments should be priced distinctly. When market segments are carefully and consistently identified dynamically, changes can more quickly and easily be identified and incorporated into the model.

In the TL industry, the statistical identification of market segments has not received adequate attention. Often, identifications of market segments are made only by a manager's experience or memory. For example, if a dedicated service is established between Chicago, IL and Omaha, NE, the manager's belief concerning the characteristics of this geographic market segment will be influenced by this service. If the service is discontinued, the manager's memory often does not adequately compensate for the change.⁴² This can lead to inappropriate pricing. The difficulty in keeping up with all of the market segments that are served is

41. Mundy, Ray A., "Managing and Evaluating Carrier Pricing," *Logistics Resource Forum*, #3, Logistics Resources, Inc., Cleveland, Ohio, September, 1983, pp. 119-135.

42. Basden, pp. 59-75; Conversations with Jeff Woods (VP of operations at LandAir Transport, Inc.), John Tweed (VP of marketing at LandAir Transport, Inc.) and Bill DeWitt (previously of the board of Burlington Motor Carriers) have all emphasized this fact in personal conversations during March and April, 1995.

due to the large number of market segments (thousands)⁴³ and the dynamic nature of these markets. Each market segment has its own unique characteristics. For example, the non-revenue miles and non-revenue time associated with transactions (two measurements that should greatly influence pricing) can vary greatly from geographic market segment to geographic market segment, and even from season to season within a given market segment. Unfortunately, current pricing suggestion systems often do not adjust rapidly enough to adequately consider these changing characteristics. This limits their utility.

A geographic market segment will be defined in this research by origin-destination pairs (such as Mobile, AL to Memphis, TN) that exhibit patterns that management can use to their advantage. Any particular origin-destination pair needs a certain level of activity before it can reveal its unique characteristics and thus be considered a geographic market segment rather than merely a small part of a larger geographic market segment. For instance, a shipment from Citronelle, AL (near Mobile) to Memphis, TN might be considered as part of the Mobile-Memphis market segment (assuming that Mobile-Memphis forms a geographic market segment) if only one shipment a year originates in Citronelle. The level of activity needed before any given origin-destination pair can or should constitute a unique geographic market segment can be determined statistically. Specific statistical methods that facilitate this determination will be discussed in part II.

43. In analyzing exhaustive data of services provided by one company, LandAir Transport, Inc., during a one year period (Jan. 1991-Jan. 1992), 12,035 geographic market segments were identified as defined by 3-digit zipcode origin-destination pairs.

EVA

It should be noted that capital yield is often referred to as profit. This differs from some popular pricing theories that suggest that profits should be based on operation ratios or contribution ratios.⁴⁴ This method of considering and including capital costs and taxes in the calculation of costs and profits has recently been referred to as *economic value added* (EVA).⁴⁵ Utilizing capital yield to define profits is a concept that dates back to 1890 when it was discussed by the well known economist Alfred Marshall.⁴⁶ The concept has received attention recently due to the increased profitability that it has brought to a number of firms that have implemented it.⁴⁷ EVA has the advantage that it calculates profits as a return on investment. For example, if an investment of \$1,000 is used for 24 hours, and the required return on the investment is 12% per annum (with no compounding), the required return for the use of this investment for 24 hours should be $\$1,000 * 0.12 / 365 = 33\text{¢}$.

Common Costs

The difficulty of "accurately" measuring costs complicates operationalizing the DPDST as proposed. One of the primary reasons for this difficulty arises from the problems associated with allocating common costs across multiple transactions. It is often argued that no allocation scheme can be shown to be "correct" so that the objective in identifying an allocation scheme is merely that

44. Temple, Barker & Sloane, Inc., *Creating Profitability: The Sales and Marketing Challenge*, Sales and Marketing Council, American Trucking Association, Inc., 1985, p. v-vi.

45. Rutledge, John, "De-jargoning EVA," *Forbes*, Oct. 25, 1993, p. 148; and Tully, Shawn, "The Real Key to Creating Wealth," *Fortune*, Sept. 20, 1993, p. 44-50.

46. Marshall, Alfred, pp. 61-62.

47. Tully, p. 38.

the scheme be logical.⁴⁸ However, some persuasively argue that the allocation of common costs using ABC allocation schemes offers significant advantages over more traditional methods.⁴⁹ Therefore, this research will use ABC techniques in the allocation of common costs.

Refinements of Cost Measurements

While it may appear that all non-common costs are identifiable, some costs believed to be identifiable are actually common. This "mistake" comes as a result of natural and seemingly harmless averaging of data and costs. For example, fuel tax rates often are not considered to be common costs even though frequently they are averaged across all states, and this average is used in the measurement of the cost of each shipment.⁵⁰ This has the effect of assigning costs to all transactions with a single fuel tax rate even though each shipment may traverse several states (each with very different fuel rates).

To illustrate the difference this can make, consider two markets, (1) Knoxville, TN to Dayton, OH and (2) Memphis, TN to New Orleans, LA. The first traverses the states of TN, KY, and OH while the second traverses the states of TN, MS, and LA. These states differ greatly in their fuel tax rates (fuel tax rates by state: TN \$0.17, KY \$0.12, OH \$0.22, MS \$0.18, LA \$0.20).⁵¹ It could be dan-

48. Patton, E. P., Brian J. Gibson, and Gregory M. Kellar, "A Methodology for Understanding and Managing Motor Carrier Costs," *Proceedings, Thirty-Fifth Annual Meeting, Transportation Research Forum (TRF)*, Louis A. Le Blanc (editor), New York, NY, Oct. 14-16, 1993, p. 47.

49. Gibson, Brian J., Gregory M. Kellar, Ray A. Mundy, and E. P. Patton, "Costing Concepts, Methods, and Teaching Techniques for Carrier Management Courses," *Logistics at the Crossroads of Commerce, Proceedings of the Twenty-Third Annual Transportation and Logistics Educators Conference*, James M. Masters (editor), CLM, Oct. 16, 1994, p. 2; see also: Mundy, et al., 1994, p. 10.

50. See: Patton, E. P., *Transportation Cost and Profit Analysis*, Graphic Creations, Knoxville, TN, Spring 1994, pp. 95, 111.

51. *Monthly Fuel Management Report*, North American Technology Corporation, January, 1994.

gerously misleading to measure a cost for a transaction from either of these markets using the averaged state fuel tax rate.⁵² Because of the variation from market segment to market segment, a more accurate picture of the cost for a particular shipment would be obtained by disaggregating the data and using the fuel tax rates on a state by state basis.

There are several other costs that need to be considered according to their usage or activity level in establishing suggested prices. For instance, driver retention and retraining costs vary from season to season and from market segment to market segment. Also, accessorial charges must be measured on a market segment by market segment basis. Fuel price variances and fuel efficiency differences should also be calculated.

Those familiar with the TLMC industry may find the mention of such apparently minor cost factors such as fuel price or efficiency variance unexpected since, for instance, a fuel price change would probably influence total cost by no more than a few percent.⁵³ The issue, however, is the sensitivity of profits to these changes. Many market segments experience about 3% of total costs as profits. This implies that, for instance, a 5% total cost swing produced by a mild fluctuation in fuel prices could cause a transaction to shift from very profitable to unprofitable.

These and other cost measurements should refine current costing practices in order for the DPDST to achieve its desired end. Employment of ABC methods (discussed in part II) will facilitate many of these refinements.

52. The reason for the concern is the sensitivity of profitability to small changes in costs. This is similar to the reasoning found in the discussion that follows and in the following footnote.

53. For example, if fuel changes from \$1.00/gal to \$1.25/gal and if fuel represents 20% of total costs, then this fuel price increase adds only 5% to the total cost.

Allocation of Non-revenue Generating Miles

Non-revenue generating activities should influence suggested prices. These activities are often called "empty miles," "deadhead miles," or "repositioning miles." Throughout this dissertation, this will be referred to as non-revenue generating miles.⁵⁴ The inclusion of these activities in setting prices is necessary as they can be large influencers of costs and their level should be measured on a market segment by market segment basis. In particular, firms develop geographic market segments in which they maintain high levels of capacity utilization (referred to as "lanes"). There is very little non-revenue activity in these lanes. However, once the firm accepts business outside of its lanes, or its lanes become unbalanced, it subjects itself to increased levels of non-revenue activity. This occurs in two ways primarily: 1) a power unit must be driven a certain distance with no revenue generating load, or 2) a power unit must sit idle awaiting a revenue generating activity. Clearly, these activities must impact suggested prices.

DPDST Attributes

Finally, to realize its full potential, the DPDST being developed should calculate prices individually according to:

- disaggregated, on-line, real-time, automatically collected data;
- up-to-date and accurate measurements;
- measurements that are available on demand; and
- disaggregated forecasts of business volumes, activity levels, etc.

54. This avoidance of the term "empty miles" comes from its multiple meanings. Some, but not all carriers differentiate among repositioning miles, empty miles, and deadhead miles. All these may be classified as non-revenue generating miles, thus avoiding any ambiguity.

Pricing decisions should be a function of many variables. In addition to some of the more common independent variables such as fuel, labor and power equipment, some of the less common exogenous variables could be:

- the month when the transaction begins or the time duration of the transaction;⁵⁵
- the distance a power unit must travel between the destination of one shipment to the origin of the next, or the time duration from the shipment delivery of the current transaction to the dispatch of the next shipment;
- driver retention and retraining;
- accessorial charges;
- capital costs; and
- taxes.

The pricing method also should include the following features:

- the definition of the function used in calculating any pricing suggestion should be user definable, and
- the method should form a "clear box"⁵⁶ and should expand rather than cloud the user's understanding of the environment as is so prevalent in many "black boxes."

The utility of this DPDST will be tested as described in the following section.

Prototype Development

Once the first two questions regarding the DPDST development are answered, a most obvious research question emerges:

55. Notice that a change in fuel economy from season to season may seem insignificant since it will change a total cost measurement only a few percentage points. However, as seen previously (see footnote 53), the profitability of this transaction can be very sensitive to these cost changes. For example, a change in fuel economy from 5.1 mpg to 5.9 mpg is a very realistic seasonal change, and the difference in the two costs often represents more than 55% of profits, according to a brief review of seasonal fuel economies and cost measurements from a major TLMC.

56. I owe my appreciation to Dr. Ray A. Mundy for introducing me to this term. He uses this term freely in discussions with his graduate classes to distinguish between decision-support systems that add managerial understanding of business processes (clear box) and those that make managerial suggestions without any increase in managerial understanding of business processes (black box).

3. Can the DPDST described be operationalized?

To propose a theoretical pricing suggestion system that cannot be implemented has limited value. Therefore, this research will demonstrate the utility of the DPDST through the creation of a fully functional software prototype.

The production of this software will furnish the ability to have industry partner(s) implement and test the pricing suggestion system. This will facilitate the measurement of any added value that the DPDST might provide to industry.

Value of DPDST

In placing the prototype on-site with industry partner(s) for evaluation, extensive efforts will be required to adapt the data of the partner(s) so that they can be used interactively and dynamically with the prototype. Because of this, the research involving evaluation of the use of the prototype will have to be restricted to a limited number of firms.

The placement of the prototype with industry partner(s) will allow the perceived and the economic value of the DPDST to industry to be measured. As used here, the term value is restricted to the content found within the research questions that follow:

1. Would an accurate, detailed pricing suggestion system actually benefit a firm?
2. What are the various uses that a firm can find for such a system?
3. What are the desirable consequences of implementing this system?
4. What are the undesirable consequences of implementing this system?
5. How would customers be influenced by this system?
6. What would the economic cost of this system be to a firm?
7. What is the economic value of this system to a firm?

In the above research questions, the first five will address perceived value while questions six and seven will address economic value. The specific measurement instruments that will be used to answer all above questions will be discussed at length in part III.

Summary

In order not only to survive but to flourish in today's business environment, a TL firm must have access to, and utilize intelligently, all the information it can in making management decisions. This is particularly true in the area of setting prices. However, little has been done in the past to assist TL firms in intelligently setting profitable prices. Recent technological advances have set the stage for advancing the current body of knowledge regarding DPDST's.

The first step in this research will be the development of a theoretically based pricing system for the TLMC industry that extends the current state of the art. After the theoretical pricing system is produced, this dissertation will show that it can be operationalized through the creation of a computer software prototype. Many state-of-the-art technologies will play an integral part in the development of this system and prototype. A few of the more prominent technologies are: (1) information theoretic statistics (ITS) (a class of neural networks), (2) information engineering, (3) graphical user interface (GUI) software engineering, (4) numerical analysis, (5) ABC, and (6) EVA. The absence of any one of these technologies would limit the utility of this project.

The third step in this research will be to measure the value of this prototype to industry. To accomplish this, the prototype will be implemented on-site with cutting-edge industrial partner(s) from the TLMC industry. The value of the prototype to the firm(s) (both the perceived and the economic value) with whom it is placed will then be measured.

The specific research questions that will be addressed in this dissertation are listed below:

1. How can currently available technologies not commonly utilized in pricing in the TL industry be harmoniously incorporated into a state-of-the-art pricing suggestion system?
2. What is the pricing system that this research will construct and suggest to advance the current state-of-the-art?
3. Can the DPDST described be operationalized?
4. Would an accurate, detailed pricing suggestion system actually benefit a firm?
5. What are the various uses that a firm can find for such a system?
6. What are the desirable consequences of implementing this system?
7. What are the undesirable consequences of implementing this system?
8. How would customers be influenced by this system?
9. What would the economic cost of this system be to a firm?
10. What is the economic value of this system to a firm?

This research will serve several purposes. First, and most directly, it will advance the state of the art in pricing in the TL industry. Second, it will measure the value that this system will bring to industry. Indirectly, this model will serve as an example of how automatically collected, historical data can be used dynamically for strategic and tactical decision-support purposes.

Part II

Literature Review

Introduction

"Pricing is the moment of truth—all of marketing comes to focus in the pricing decision."¹

The body of literature that contributes to the development of this DPDST for the TL industry comes from several different fields and bodies of knowledge. The primary sources of the contributing technical streams of thought can be found in: transportation pricing, activity based costing (ABC), economic value added (EVA) capital costing, information engineering, information theoretic statistics (ITS), numerical mathematics, and forecasting. In brief, their respective contributions to this research are:

Transportation Pricing:	Economic theories and philosophies and current environmental conditions that influence pricing attitudes and methodologies.
Activity Based Costing (ABC):	Measuring costs according to the level of resources that a particular activity requires.
Economic Value Added (EVA):	Modernization of a concept that dates back to Marshall. It includes capital costs in cost measurements.
Information Engineering:	Study of means to efficiently collect and distribute data electronically
Information Theoretic Statistics (ITS):	A class of neural network that allows optimal probabilistic ordering of various statistical models.

1. Corey, E. Raymond, *Industrial Marketing: Cases and Concepts*, Prentice Hall, Englewood Cliffs, NJ, 1962.

Numerical Mathematics:	Study of algorithms and theorems to produce faster and more accurate calculations using mechanical (or electronic) computations.
Forecasting:	Study of techniques to predict future outcomes from present knowledge, expectations and historical data.

Each of these listed technologies will play an integral role in the completion of this research. The first category (transportation pricing) will give the direct background upon which this research will build. The other items will be grouped under the category of contributing technologies and will allow this research to extend the current state of the art. Figure 3 graphically represents the interplay among the various streams of thought contributing to this research. A discussion of these topics follows.

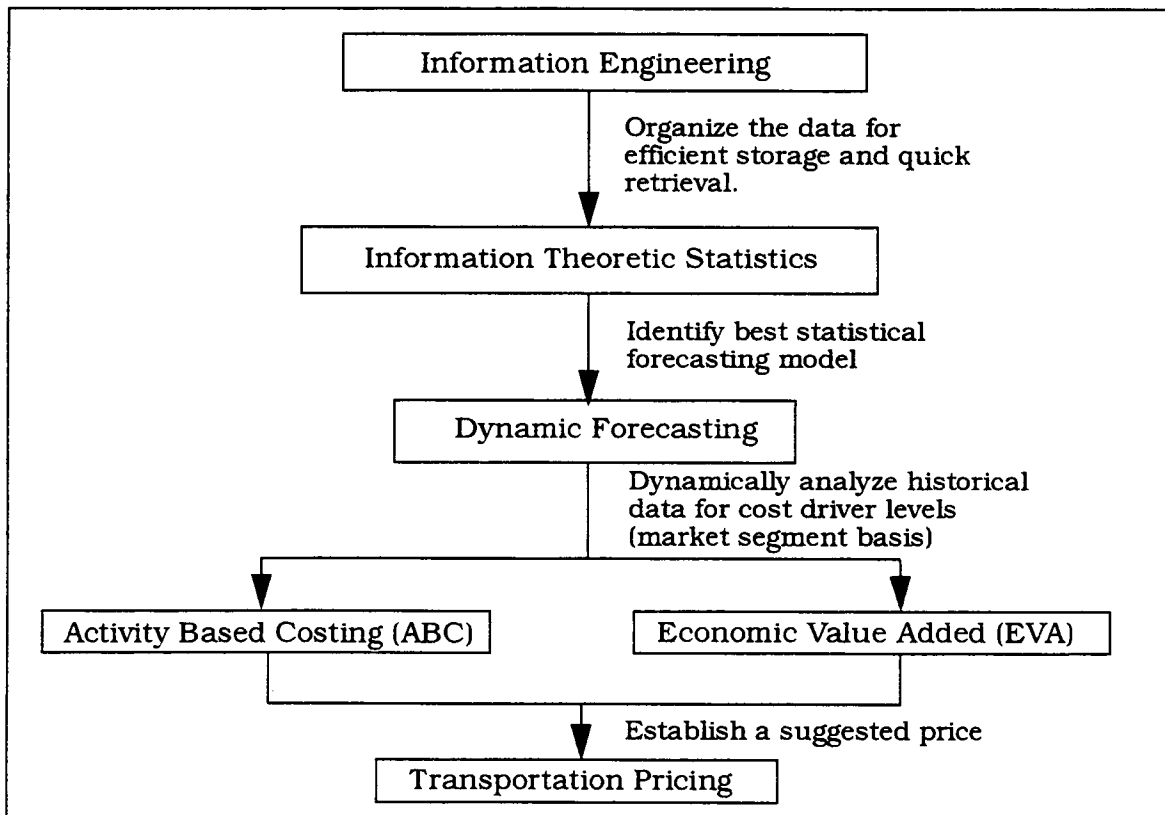


FIGURE 3 Interplay of Contributing Streams of Thought

Dimensions of Pricing

As early as 1974, it was stated:

"More and more, today's pricing environment demands better, faster, and more frequent pricing decisions than ever before. [This] is...forcing companies to take a new look at pricing and its role in an increasingly complex marketing climate."²

In 1977 this thought was reiterated when it was stated that "[a]bove all...an ability to adapt to the new pricing environment will characterize those companies that succeed in competing over the next decade."³ The importance of pricing in a firm's marketing mix is even greater today than at the time these statements were made. In part, this is because "[p]rice is the only marketing strategy variable that generates income. All the other variables in the marketing mix generate costs—advertising, product development, sales promotion, distribution, [and] packaging—all involve expenditures."⁴

This suggests that a means to make "better, faster, and more frequent pricing decisions"⁵ should be studied and pursued. The discussion which follows on pricing theory provides a foundation upon which this pursuit may be established.

2. "Pricing Strategy in an Inflation Economy," *Business Week*, April 6, 1974, p. 43.

3. "Flexible Pricing, Industry's New Strategy to Hold Market Share Changes the Rules for Economic Decision-Making," *Business Week*, December 12, 1977, p. 78.

4. Monroe, Kent B., *Pricing: Making Profitable Decisions*, McGraw-Hill Book Company, New York, 1979, p. 6.

5. "Pricing..." p. 43.

Pricing Theory

In order to understand past and current pricing models, one must understand the theoretical foundation of pricing. The following discussion reviews key points from the pricing theory literature.

Definition

As mentioned in part I, price is defined as the economic value of a product or a service, in other words, the maximum price that customers will pay, if these customers are "economic men and women," that is, fully informed consumers who completely and rationally analyze all purchase decisions...."⁶ Such a definition leads to a distinction between the terms "offer" and "price," since it is possible to make an offer that would never be accepted. For example, an offer of a non-descript stick of chewing gum for \$1,000,000 would not constitute a price of \$1,000,000 unless someone accepted the offer and purchased the chewing gum. Thus, it must be assumed that an offer is not a price if it is not accepted, i.e.: if it exceeds the value that consumers place on the product or service. This restrictive definition of price being distinct from offer allows precision in thoughts, communications, and in theory and system development by distinguishing between the two.

Management should know its customers well enough that if a serious offer is made, the offer constitutes a price. Ideally, this offer or price should be determined by several components, including costs, demand/elasticity, customers, value of service, and competition. A brief discussion of each of these follows.

6. Nagle, Thomas T. and Reed K. Holden, *The Strategy and Tactics of Pricing: A Guide to Profitable Decision Making*, Prentice Hall, Englewood Cliffs, New Jersey, 1995, p. 75.

Costs

Cost estimation is an important component of pricing and must be closely studied and understood. "A cost estimating system worth anything must reflect accurately and currently all changes in the company so that management may price effectively in its markets, channel its sales effort for maximum profits, enhance profitable facilities, discard unprofitable facilities, and plan for expansion. Management must know its costs while the events...are current, not 'after the fact' when the events have become ancient history. A proper cost estimating system must be able to predict in advance, within close limits, the ultimate costs of running an order."⁷

Many distinct categories of costs and cost concepts exist, and must be considered when attempting to estimate costs. These include common costs, identifiable costs, variable costs, fixed costs, direct costs, indirect costs, short-run cost, long-run costs, and allocation schemes. Each of these concepts play a distinct role in price formulation. These concepts are defined below:

Common Cost: "Costs that cannot be identified with an individual shipment are called common, shared, or non-identifiable."⁸

Identifiable Cost: "Costs not classified as common costs are identifiable costs."⁹

7. Tucker, Spencer A., *Cost-Estimating and Pricing With Machine-Hour Rates*, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1962, p. 6.

8. Patton, E. P., *Logistics/Trans. 402, Motor Carrier Costing and Profit Analysis*, University of Tennessee, Knoxville, Graphic Creations, Knoxville, TN, Fall, 1990, p. 11.

See also: Cavinato, Joseph L., Editor, *Transportation-Logistics Dictionary, Third Edition*, International Thomson Transport Press, Washington, D. C., 1989, p. 54.

9. Patton, 1990, p. 11.

Variable Cost: "The payments to variable factors of production."¹⁰ "Variable costs...are those costs which are known to vary fairly directly with volume."¹¹ These "are costs of doing business."¹²

Fixed Cost: Payments to factors that do not change in the short-run.¹³ "In general, fixed costs may be defined as those costs which do not vary with volume, but rather are incurred with time. They are also known as stand-by costs or period costs." These "are costs of being in business."¹⁴

Direct Cost: "[T]hose which are the result of a direct contribution to the manufacture of a product. For example: a setup is made, a bar is loaded, a piece turned, a product inspected."¹⁵

Indirect Cost: "[T]hose generated by activities which, although necessary for the operation of a factory, are not a direct result of the manufacture of a product. Such expenses are the sweeping of a floor, the issuance of a tool by the tool crib attendant, the repairing of a machine, supervisory checking of dimensions on a print, and the like."¹⁶

Short-run: "The short-run refers to that period of time in which the level of usage of one or more of the inputs is fixed. Therefore, in the short-run, changes in output must be accomplished exclusively by changes in the use of the variable inputs."¹⁷

10. Maurice, pp. 270-271.

11. Tucker, p. 3

12. Nagle and Holden, p. 19

13. Maurice and Smithson, pp. 270-271.

14. Nagle and Holden, p. 19.

15. Tucker, p. 6.

16. Tucker, p. 6.

17. Maurice and Smithson, p. 228.

Long-run: "[T]he long-run is defined as that period of time (or planning horizon) in which all inputs are variable."¹⁸ (In the long-run all costs become variable).

Allocation Scheme: An allocation scheme is defined as the choice of how and where to assign common and fixed costs. "In transportation accounting, [this is] the apportionment of the expenditures and revenues to the respective divisions of the organizations, such as maintenance of way and structure costs being divided between freight and passenger service[,] since they are used by both."¹⁹

Once costs are estimated, they establish the pricing floor.²⁰ Additionally, a pursuit of profitability demands that prices cover total costs whenever possible. One allocation scheme achieving increasing popularity is activity costing. "Activity costing or activity-based costing is a cost allocation methodology that focuses on improving how a firm allocates overhead, selling, and administrative costs."²¹ This will be discussed in greater detail later (see "Activity Based Costing", p. 62) since this research will attempt to take advantage of ABC methods.

In spite of the appeal of cost-based pricing systems, cost information is, by its very nature, insufficient and can even be dangerous when used as the sole basis of price setting. This, too, will be discussed in some detail later (see "Appeal and Danger of Cost-Based Pricing", p. 46). Although costs constitute an essential component of pricing, and there are some clear advantages to cost-

18. Maurice and Smithson, p. 228.

19. Cavinato, 1989, p. 12.

20. This point is illustrated in figure 6, page 43; See: also footnote 22 on p. 42.

21. Campbell, Robert J., *Competitive Cost-Based Pricing Systems for Modern Manufacturing*, Quorum Books, Westport, Connecticut, 1992, p. 6.

based pricing, the other elements of pricing (demand/elasticity, customers, value of service, and competition) must be considered as well.

Demand (Elasticity)

Two components of price that must be considered in addition to cost are demand and elasticity. Demand can be viewed as a measurement of the volume of sales that will occur over a range of prices. Elasticity measures how sensitive demand is to price. A typical demand curve appears as shown below in figure 4.

Introductory economics teaches that if demand could be measured precisely, setting prices would be a simple matter of optimizing profits by setting prices (or marginal revenue) equal to marginal costs. Unfortunately, demand is difficult to measure. Further complicating the issue, demand changes over time. Demand can change for a variety of reasons, such as changing customer preferences, competitive forces, or economic conditions. Prices rarely can rely solely on

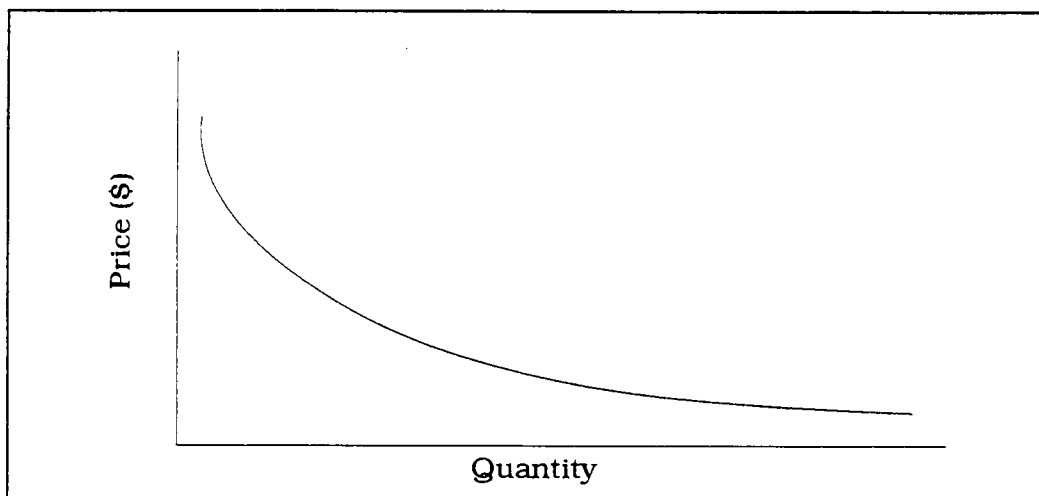


FIGURE 4

Demand Curve

Adapted from S. Charles Maurice and Charles W. Smithson, *Managerial Economics, Applied Microeconomics for Decision Making, Third Edition*, Richard D. Irwin, Inc., Homewood, IL, 1988, p. 144.

customer demand. Instead, as seen in figure 5, prices must balance both the external forces of customer demand and the internal forces of costs.

Accurate measurements of demand are difficult to calculate because of incomplete information and competitive forces. Thus, the measurements of the influences that demand should have on price are inexact at best. These measurements require an in-depth knowledge of the markets segments being served, and a great deal of managerial expertise must be brought to bear.

Customers, Competition, and Value of Service

As previously mentioned, customers (in combination with product or service providers) ultimately determine the value of a product or service. Customers will purchase a product or service only if it is offered below their "point of indifference." Clearly, different customers will value the same product or service distinctly. This forces business units to identify and target groups of customers that place similar economic value on a given offering, i.e.: target markets. These customers become the firm's greatest assets.

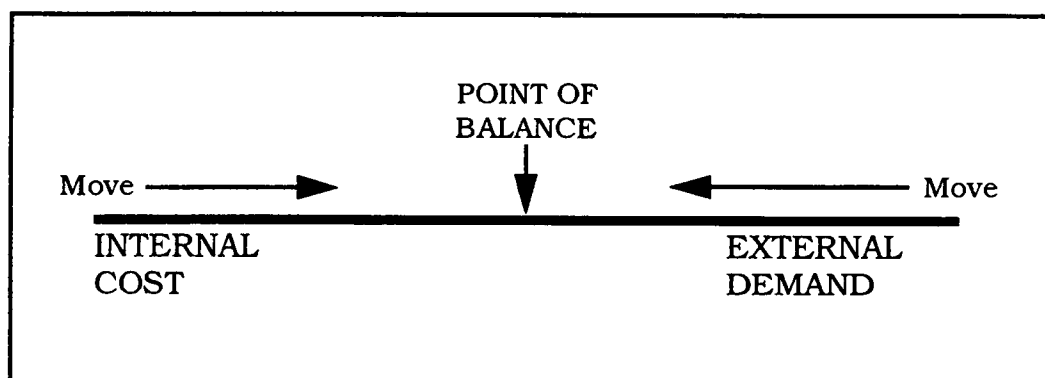


FIGURE 5

Balancing Internal Costs and External Demand

Adapted from: Robert J. Campbell, *Competitive Cost-Based Pricing Systems for Modern Manufacturing*, Quorum Books, Westport, Connecticut, 1992, p. 182.

Customer satisfaction, customer retention and loyalty, and pleasing one's customers all must be pursued vigorously. Establishing prices for a target market requires that management understand the customers' perceptions of value.

Competitive forces constantly threaten to undermine efforts to maintain and expand a customer base. If an offer for a product or service is considered "exchangeable" with a competing offering, then the market will force the price of both offerings to be priced similarly (assuming that excess capacity exists). Competition also influences price elasticity by sensitizing customers to price differences, causing the demand curve (discussed above) to shift, thus changing optimal prices. In this way, competitive offerings influence the "value of service" or the price that "the market will bear," which functions as the price ceiling, or the highest price that a firm can rationally charge for an offering.

Charging the greatest amount that a customer will pay, or charging what "the market will bear" is often referred to as "value of service pricing." Usually, costs are less than the value of service. If the value of service is less than costs, (i.e.: costs are greater than what the market will bear) the offering should not be extended.²² The region between these two numbers (costs and value of service) forms a "zone of negotiation,"²³ and defines the latitude given to management in price formation. Figure 6 illustrates this in the motor carrier industry.

The setting of a price within the zone of negotiation needs to balance all the components that have been discussed. Optimizing profits, balanced by corporate strategy, demand, and customer considerations, should dictate the actual offer.

22. Variable costs define the lower limit for reasonable prices if excess capacity exists. Total costs define the lower limit for reasonable prices if excess capacity does not exist. See figure 6, page 43.

23. Patton, 1994, p. 18.

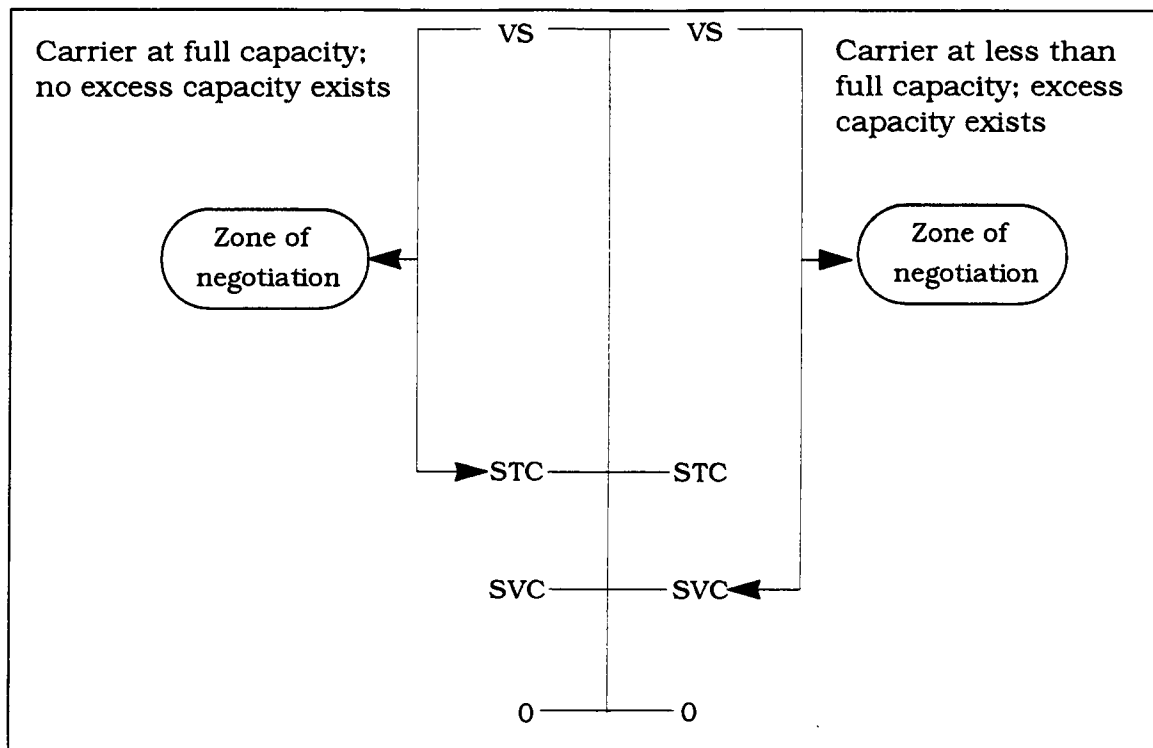


FIGURE 6

The Zone of Negotiation

NOTE: VS is the value of the transportation service to the shipper

STC is the total cost to the carrier to move the shipment.

SVC is the variable cost to the carrier to move the shipment.

Adapted from: E. P. Patton, *Logistics/Trans. 402, Motor Carrier Costing and Profit Analysis*, University of Tennessee, Knoxville, Graphic Creations, Knoxville, TN, Fall, 1990, p. 63.

Pricing Strategies

Establishing Price Strategies

Pricing decisions should be set with corporate strategy as the driving force. Ultimately, a measure of the success of pricing decisions indicates the degree to which corporate objectives are accomplished. Since rational pricing is subject to managerial judgement (because of the latitude allowed by the zone of negotiation and the imprecision in the measurements that define the zone of negotiation),

establishing corporate objectives should precede all other steps in the decision process. The next sub-section discusses in detail some of the more common pricing strategies and a model for developing a pricing strategy.

A primary purpose of any pricing strategy is to bridge the gap between marketing and finance functions.²⁴ An enormous number of different pricing strategies exist. Some of the more popular ones that have been developed include penetration pricing, neutral pricing, skim pricing,²⁵ geographical pricing, promotional pricing, discriminatory pricing, product-mix pricing,²⁶ cost-based pricing,²⁷ value of service pricing,²⁸ price-stability strategies, and new product pricing strategies.²⁹ A proper understanding of three of the more basic of these strategies is needed in order to establish the theoretical basis of the DPDST herein developed. These are cost-based pricing (generally a neutral pricing strategy), penetration (low end) pricing, and value of service (high end) pricing. These strategies will be discussed in some detail.

Cost-Based Pricing

Cost-based pricing strategies are popular and wide spread. They usually take on one of the following two forms:

1. cost plus pricing—"the marketer simply determines the unit costs for producing an item (variable and fixed costs per unit) and adds a margin to meet a profit objective,"³⁰ or in other words, all costs are deter-

24. Nagle and Holden, p. 2.

25. Nagle and Holden, pp. 154-160.

26. Kotler, pp. 512-517.

27. Campbell, pp.2-7.

28. Locklin, pp. 159-160.

29. Assael, Henry, *Marketing Principles & Strategy*, The Dryden Press, Chicago, IL, 1990, pp. 539-547.

30. Assael, pp. 556-557.

mined and allocated to each unit, then a fixed profit margin is added to this cost to obtain the price.

2. target return pricing—"many firms set a target return on their investment or on [their] costs, and then price to achieve this target. Target return pricing determines the price that will achieve a profit target at a specified volume level."³¹ The target return assumes that a given sales volume will be achieved, then the price is set that will give the "target return" at that sales volume. This is different from cost-plus pricing which prices to achieve a fixed return at all sales volumes.

Because of its simplicity, cost-based pricing is a very common pricing strategy. Some people feel that this is the fairest pricing system for both buyers and sellers. "Sellers do not take advantage of buyers when the latter's demand becomes acute; yet the sellers earn a fair return on their investment."³² Cost-based pricing also minimizes price competition when all firms in one industry use this pricing strategy, as prices tend to be similar.³³

There are other advantages of using cost-based pricing. One positive aspect is that because measurement of company costs is so important, the measurement is often more accurate than in firms where other pricing strategies are emphasized. Further, cost information is generally readily available not only for costing, but for other management uses as well, creating a potential to improve managerial decision making. In this context, properly measured costs can become "an effective competitive tool,"³⁴ and can lead to continuous improvement within a firm.³⁵

One example of how cost information can improve decision making is in determining the best product mix (given the current constraints existing in the

31. Assael, p. 558.

32. Kotler, p. 505.

33. Kotler, p. 505.

34. Campbell, p. 253.

35. Mundy, et. al., 1994, p. 9-10.

firm). This determination can then assist communication between marketing and production so that marketing does not pursue "a mix of product orders that severely hampers the profitability of the firm."³⁶ Also, cost information can help marketing and production coordinate "what the firm is capable of selling with what it can produce,...[by] identifying the major bottlenecks [and] working together to identify and then push the most profitable volume through that bottleneck, while at the same time planning for future expansion in critical areas."³⁷

Other areas where cost information can be used to benefit a firm include identifying how best to use scarce or limited resources, in deciding how to relieve critical constraints, and in discovering areas for cost reduction.³⁸ The accomplishment of these objectives requires the correct identification of product or service winners and losers. This identification is determined, in part, by the choice of an allocation scheme. In particular, "[t]he allocation of costs to products is needed to determine whether current selling prices are adequate. The knowledge of what products are winners and losers and how best to use scarce resources should not be lost in the process of cost allocation."³⁹ As alluded to above, cost-based pricing can facilitate these identifications.

Appeal and Danger of Cost-Based Pricing

In spite of the advantages associated with cost-based pricing, there are significant dangers to consider before and while implementing such a strategy. Since costs are measurements of internal activities, and are thus more easily

36. Campbell, p. 253.

37. Campbell, p. 253.

38. Campbell, p. 161.

39. Campbell, p. 253.

evaluated than external market reactions, the influence of costs in pricing can be overemphasized easily.

Basing prices on costs alone can be dangerous, and in extreme cases, even devastating.⁴⁰ In particular, one of the major pitfalls is that cost-based pricing systems are generally inflexible and do not allow for price influences on sales volume, nor influences of sales volume on costs, and therefore on price. This inflexibility generally does not allow for managerial judgement in pricing, nor does it allow pricing to vary according to marketing strategy.

An example of the danger associated with cost-based pricing can be seen in the case of Wang Laboratory. Wang, a leading producer of word processors in the late 1970's, utilized a "cost-plus" pricing scheme, wherein overhead and variable costs were allocated to each unit sold, and the cost was increased by a set amount to arrive at a price. When the company's growth slowed and sales decreased in the mid-1980's, unit sales predictions had to be reduced. Instead of lowering prices in an attempt to increase sales, fixed costs were simply reallocated over a smaller number of units, actually increasing the per unit price. Understandably, sales decreased further. Wang again recalculated unit costs and raised prices to cover its overhead, leading to further reduced sales, and so on. Eventually, even loyal Wang customers switched to cheaper alternatives.⁴¹

As demonstrated in the Wang example, the traditional difficulty associated with cost-based pricing schemes is that of allocating indirect costs.⁴² This difficulty arises both from the assumption that volume levels are constant, and from the neglect of the interplay among the various components of price (demand,

40. Monroe, pp. 12-14, 272-273, 276.

41. Nagle and Holden, p. 3.

42. Locklin, p. 164.

sales volume, market pressures, etc.) Thus, prices based on costs in isolation, without considering other pricing components can result in sub-optimal profits or even economic losses. Generally, a change in price will lead to a change in sales volume, invalidating the intended meaning of the cost-plus pricing strategy. A price increase may reduce sales, causing unit costs to rise. This could result in a decrease in profits rather than the hoped for increase. However, a price cut may result in an increase in sales, yielding greater economies of scale and decreasing per-unit costs, with resulting increased profits. Thus, "pricing affects sales volume, and...[sales] volume affects costs."⁴³

Often, this allocation problem becomes quite subtle, involving the allocation of identifiable costs as well as indirect costs. This can occur from an over-reliance on a combination of traditional accounting systems and the use of cost-based pricing. For example, a customer recently went to a local Knoxville, TN computer store to purchase a hard disk drive. He reported observing two hard disks for sale. The smaller capacity disk was offered at twenty dollars more than the higher capacity disk. When questioned about this, a salesman stated that the store had purchased the smaller disk drive some time before the larger one, and at a higher cost (to the computer store) than the larger one. Therefore, in order to recover their [directly identifiable] costs, they were offering the smaller capacity disk drive at a higher price. Although the customer had intended to purchase the smaller capacity hard disk drive (and would have, if the store's offers had reflected the current market value), he chose to save money and purchase the larger capacity disk drive!⁴⁴ This example demonstrates that costs

43. Nagle and Holden, p. 3.

44. As reported by Ray Wolfe to the author on July 2, 1995; episode occurred at CRS of Knoxville, TN during the preceding week.

must be reported as identifiable according to management's decision making needs, not traditional accounting methods. Whether dealing with allocations of "indirect" or direct costs, relying strictly on cost information (especially faulty cost information) to set prices is unwise.

As Locklin said in the early 1900's regarding pricing in the transportation industry: "The fundamental fallacy in any [allocation scheme] that do[es] not vary with the volume of traffic lies in the fact that the cost depends upon the volume of traffic, and the volume of traffic depends upon the rate charged.... The advocates of cost [-based pricing] argue that their method is the only 'scientific' way of making rates, but nothing could be more unscientific than an attempt to base rates on cost in disregard of the conditions of demand."⁴⁵ This issue has been a subject of concern for over a century, and continues to stimulate research.⁴⁶

In spite of this, cost-based pricing is not without merit, and is a widely used strategy.⁴⁷ This is due, in part, to the fact that no matter what the pricing strategy, all costs must eventually be covered. For most businesses, the easiest way to assure this is to base price on cost. Business can be run profitably, within

45. Locklin, p. 164-165.

46. See for example: Acworth, W. M., "The Theory of Railway Rates," *Economic Journal*, pp. 317, 323, 1897; Hadley, A. T., "American Railroad Statistics," *American Statistical Association Publications* (new series), pp. 241, 249, 1889; as cited in Locklin, p. 164.

See also: Schneider, Arnold, "Simultaneous Determination of Cost Allocations and Cost-Plus Prices for Joint Prices," *Journal of Business Finance & Accounting*, Vol. 13, Issue 2, Summer, 1986, pp. 187-195.

See also: Schneider, Arnold, "Pricing and Indirect Cost Allocation," *Accounting & Finance*, Vol. 27, Issue 1, May, 1987, pp. 49-55.

See also: Nagle and Holden, p. 3ff.

47. Kotler, p. 505.

limits, using this strategy. However, there are clearly times when other strategies would be more advantageous.

Penetration Pricing

New product or service offerings often will need to establish market presence. Frequently, this is done through aggressive pricing practices. Pricing aggressively to establish market presence is known as penetration pricing. "For nondurable goods with frequent repeat purchases, the optimal price path would be an introductory low price (penetration) followed by monotonically increasing price."⁴⁸

In this situation, a fully allocated cost will not suggest the appropriate price. Sometimes, a penetration price will barely cover variable costs. While this is an excellent strategy for developing a new market, care must be taken with this strategy as it may be difficult to raise prices to profitable levels once a customer base is established.⁴⁹

Value of Service Pricing

Mature products and service offerings that do not suffer from competitive threats will often charge what the market will bear. This pricing strategy is known as value of service pricing. Sometimes this equates to a managerial pricing strategy to sell to price-insensitive customers in spite of price reduction influences on volume and profits. However, even when this pricing strategy yields optimal profits, it can be risky, since it frequently attracts competitors. It is difficult to build much customer loyalty with this pricing strategy, so when

48. Devinney, Timothy M., *Issues in Pricing: Theory and Research*, Lexington Books, D. C. Heath and Company, Lexington, Massachusetts, 1988, p. 372.

49. Kotler, pp. 514-515.

competition develops, this pricing strategy must be modified if a firm intends to maintain its market presence.⁵⁰

Developing Effective Pricing

Certain steps should be taken prior to choosing a particular pricing strategy or policy. These steps can be graphically seen in figure 7, which describes the interrelationships among the several aspects of a successful pricing policy. In particular, the components mentioned above (costs, demand/elasticity, customers, and competition) should influence pricing strategies. These should then be translated into specific and measurable goals. These goals must in turn be tactically implemented. The end result of this is a successful pricing policy.

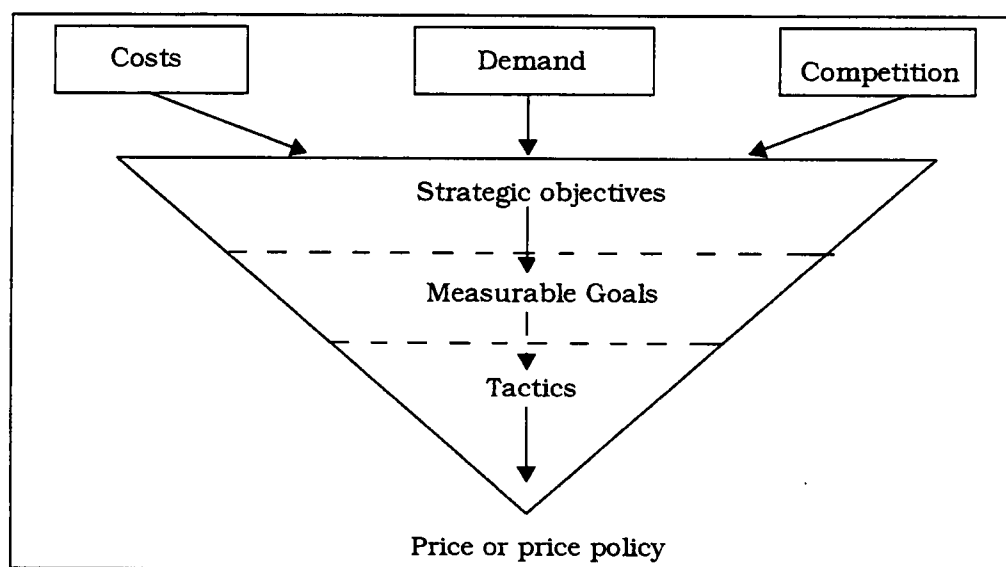


FIGURE 7

Developing an Effective Pricing Strategy

Adapted from Thomas T. Nagle and Reed K. Holden, *The Strategy and Tactics of Pricing: A Guide to Profitable Decision Making*, Prentice Hall, Englewood Cliffs, New Jersey, 1995, p. 10.

50. Assael, p. 315.

Once corporate objectives and target markets are identified, costs are measured, and competitive influences are considered, prices can be set. Variable costs will define a pricing floor. Competitive forces and customer demand will define the pricing ceiling. Corporate strategy will help to identify the actual offer, for example, if the offer should barely cover variable costs in order to gain market share or if the offer should be closer to "what the market will bear" in order to reap maximal profits in the short term. Furthermore, as Henry Assael observes, companies should "evaluate [their own] prices by assessing the responses of customers and companies to the price levels they set."⁵¹

51. Assael, p. 576.

Pricing in the TL Industry

The TL industry has changed dramatically since 1980. Economic and competitive pressures since deregulation have increased the importance of management expertise in price setting.

Deregulation

As mentioned in the beginning of the section titled "Dimensions of Pricing", the importance of effective pricing applies particularly to today's TL industry. Beginning with the Motor Carrier Act of 1980 (MCA), pricing decision making in the TL industry has changed from regulated joint rate making strategies to individual market driven decisions. Adding to the market dynamics introduced in 1980, President Bill Clinton signed the Trucking Industry Regulatory Reform Act of 1994 (TIRRA) on 26 August 1994. Except for the transportation of household goods, passengers, or service to non-contiguous states or territories, TIRRA eliminates the tariff filing requirement for motor common carriers using an individually determined rate, classification, rule or practice.⁵² The combined effect of the MCA and TIRRA allows greater pricing freedom than ever before.⁵³

52. Calderwood, James A., "Shipper Beware," *Transportation & Distribution*, Vol. 35, Issue 11, Nov., 1994, p. 83.

53. Bohman, Ray, "New Rules for Doing Business," *Traffic Management*, Vol. 33, Issue 12, Dec., 1994, p. 27.

Economic Pressures

The license to create prices with few governmental restrictions has the potential to introduce a destructively competitive situation. Economic theory states that when excess capacity exists, ruinous competition can emerge. The consolidation that has occurred in the TLMC industry since 1980 can be considered a sign of such competition and its results. Further consolidation in the TL industry is predicted to continue throughout the rest of this decade.⁵⁴

In trying to deal with this threat of ruinous competition, several operating challenges have manifested themselves in the TLMC industry since 1980, some of them relating directly to pricing problems. For example, shippers are increasingly relying on long term contracts. Pricing decisions for long term, dedicated services are different from those for spot markets since the risk associated with a single spot market pricing decision is much smaller than the risk associated with a dedicated service pricing decision.⁵⁵ The result is that profitable pricing is becoming more complicated, demanding greater attention.

Another challenge faced by management in trying to set prices comes as a result of a decrease in operating costs (per ton mile), since deregulation. While classically motor carrier transportation services do not experience economies of scale,⁵⁶ longer haul shipments and an increase in loads per vehicle do result in lower costs per ton mile. Larger firms appear to have a distinct advantage in

54. "Truckload Will See a Shake-Out", *Transportation & Distribution*, Vol. 35, Issue 2, Feb., 1994, p. 14.

See also: Duncan, pp. 37-43.

55. Crum, Michael R. and Benjamin J. Allen, "Shipper EDI, Carrier Reduction, and Contracting Strategies: Impacts on the Motor Carrier Industry," *Transportation Journal*, Vol. 29, Issue 4, Summer, 1990, pp. 18-32.

56. Allen, W. Bruce and Dong Liu, "Service Quality and Motor Carrier Costs: An Empirical Analysis," *Proceedings, Thirty-Fifth annual meeting, Transportation Research Forum (TRF)*, Louis A. Le Blanc (editor), New York, NY, October 14-16, 1993, p. 25.

attracting this traffic. Thus industry averages are not appropriate for individual firm costing. Also, the use of corporate averaged ton-miles for cost allocation purposes should not be held constant, but rather should be constantly updated to maintain non-biased cost measurements.⁵⁷ These and other challenges have been increasing as the effects of deregulation become more evident, and emphasize the need for a DPDST.

Recently the TL industry has been given a respite from the problems of excess capacity and the risk of ruinous competition as a state of capacity shortage has emerged. In 1993, demand for TL service rose due to a growing economy. TL carriers continued to win new business, particularly in the long haul market.⁵⁸ Further helping carriers, manufacturers and distributors have begun sending out larger shipments.⁵⁹ The economic rebound is driving carrier negotiating strength and increased carrier profits.⁶⁰

The situation of system capacity constraints is not expected to continue. Some of the reason for the capacity shortage in the industry has to do with a growing economy as well as seasonally increased demand (TL equipment shortages seem to increase with the Fall shipping season). Another reason is the lack of qualified drivers, which tends to damage a firm.⁶¹ For example, J. B. Hunt Transport Services Inc. has had to park as many as 100 of its 4,150 trucks at a time due to driver shortages.⁶² The shortage of truck drivers is related to low

57. Xu, Kefeng; Robert Windle; Curtis Grimm and Thomas Corsi, "Re-Evaluating Returns to Scale in Transport," *Journal of Transport Economics & Policy*, Vol. 28, Issue 3, Sept., 1994, pp. 275-286.

58. Hoffman, Kurt, "Still In It For the Long Haul," *Distribution*, Vol. 93, Issue 7, July, 1994, pp. 22-25.

59. Arendes, Michael J., "Traffic & Revenues Rebound," *Fleet Owner*, Vol. 89, Issue 1, Jan., 1994, pp. 30-31.

60. "Operating Revenues, Freight Rates Increase," *Fleet Owner*, Vol. 89, Issue 10, Oct., 1994, pp. 266-267.

61. "TL Shortage Getting Shorter," *Distribution*, Vol. 93, Issue 11, Oct., 1994, p. 16.

driver pay, onerous lifestyle demands, and lack of respect. Typically, a driver will operate 100,000 miles a year, travel away from home for days or weeks at a stretch and will earn \$25,000 to \$30,000 annually. Many carriers feel that drivers need to be guaranteed \$40,000 to \$50,000 annually to correct the current driver shortage.⁶³ This fact is currently driving price increases.⁶⁴ However, the ATA recently predicted that rates are not likely to climb rapidly in the near future.⁶⁵ This means that any increase in driver salaries is likely to decreased margin profitability rather than increase it.

Proactive managers of TL firms should use the present upswing in the economy to develop the tools and abilities to combat the threat of excess competition. Clearly, the ability to create pricing decisions profitably and competitively should receive a large part of this attention.

Profitable Pricing in the TL Industry

As already demonstrated, establishing profitable prices in the TL industry is an area that merits greater attention and emphasis.

Need for more Efficient Pricing

Price setting in the TL industry can be time consuming due to the many components that must be considered. Detailed cost information must be gath-

62. Harris, John, "J. B. Hunt Transport: Rough Road," *Forbes*, Vol. 146, Issue 12, Nov. 26, 1990, pp. 206-211. Worth mentioning is the fact that J. B. Hunt has taken several successful steps to combat this problem.

63. Duncan, Thomas W., "Can Trucking Pay What Drivers Want?" *Fleet Owner*, Vol. 89, Issue 5, May, 1994, p. 6.

64. Moskal, Brian S., "What Driver Shortage?" *Industry Week*, Volume 243, Issue 21, Nov. 21, 1994, pp. 17-18.

65. Bradley, Peter, "Carriers Feel the Squeeze," *Purchasing*, Vol. 116, Issue 4, Mar. 17, 1994, pp. 37-43.

ered, competitive influences must be understood, demand must be measured, and markets with the greatest potential for improved profitability must be identified. Too often, the time required by these analyses forces prices to be set with incomplete information or the decision making process is delayed to the point that the analyses are no longer relevant. A need exists to carry out these analyses with greater accuracy and with greater speed. The development of a DPDST for the TL industry addresses this need.

DPDST for the TL Industry

As mentioned previously, the intelligent use of managerial judgement is complicated by the constant interplay among business volumes, prices and business activities. Figure 8 illustrates this interplay. A DPDST should assist in harmonizing these competing forces while simultaneously bringing increased speed to price setting in the TL industry.

Nagle and Holden suggest that the use of dynamically collected and analyzed data may offer a solution to these difficulties. In this regard, Nagle and Holden divide pricing strategy creation into three stages: first—data collection, second—strategic analysis of the data, and third—strategy formulation, as presented in figure 9.

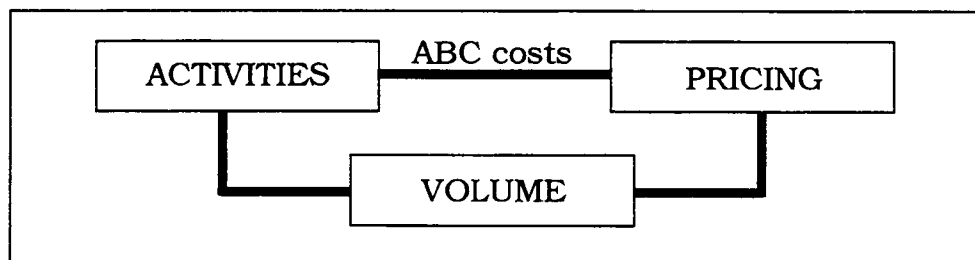


FIGURE 8

Relationship Among Activities, Pricing, and Volume
Adapted from Robert J. Campbell, *Competitive Cost-Based Pricing Systems for Modern Manufacturing*, Quorum Books, Westport, Connecticut, 1992, p. 169.

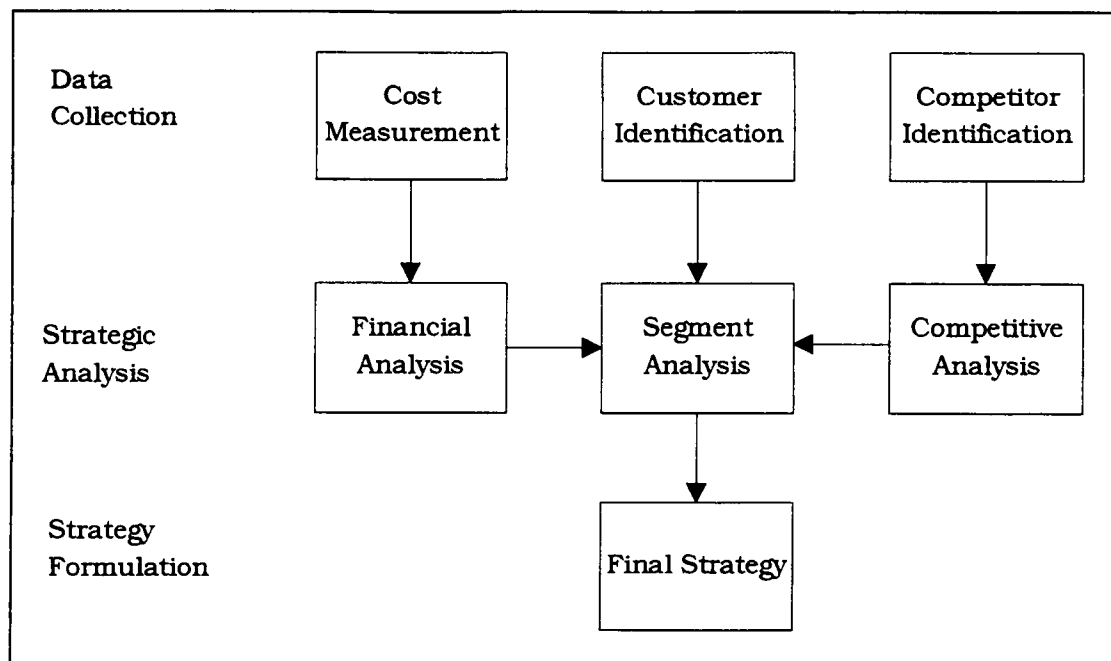


FIGURE 9

Steps to More Profitable Pricing

Adapted from Thomas T. Nagle and Reed K. Holden, *The Strategy and Tactics of Pricing: A Guide to Profitable Decision Making*, Prentice Hall, Englewood Cliffs, New Jersey, 1995, p. 142

Another issue in price formulation was raised by Campbell when he suggested that costing measurements utilized in price setting should be supplemented with a study of variances of costs.⁶⁶ Such a study would facilitate sensitivity analyses which should greatly assist management in the decision making process.

The DPDST being developed in this research is consistent with Nagle and Holden's model of strategy development. By automating and improving the first two steps, the last step is greatly facilitated. The system, through the use of information theoretic statistics (ITS), will dynamically analyze automatically col-

66. Campbell, pp. 6-9, 89-117.

lected data to identify customers and market segments and will measure costs using activity based costing (ABC) concepts.⁶⁷ Further, the DPDST will allow the sensitivity analyses proposed by Campbell. All of this will be done in real-time, allowing a rapidity of response seldom available in the TL industry.

Recall that the DPDST is not intended to replace managerial judgement. Instead, it is intended to enhance management's decision-making abilities. This is consistent with Tersine when he stated that "[m]athematical techniques are only aids to management decision making. They cannot replace the judgement and intellect of the manager, who must modify and improvise to deal with the unexpected."⁶⁸

The ability to harmonize and operationalize dynamically differing and sometimes competing pricing philosophies of various experts offers many advantages to management. In addition to enhancing pricing decisions, such "harmonizing" also allows marketing efforts to be focused in new and creative ways to enhance profitability. Mundy's adaptation of the Boston Consulting Group model, as discussed below, provides an example of this.

Focusing Marketing Efforts

A primary objective of TL motor carriers should be to identify freight that is profitable and freight that is not profitable (or profitable versus unprofitable market segments or customers). Mundy suggested over a decade ago that the familiar diagram attributed to the Boston Consulting Group, as seen below in figure 10, could aid management in solving this problem by assisting with price

67. ABC and ITS will be discussed later in part III, on page 62 and page 74, respectively.

68. Tersine, Richard J., *Materials Management and Inventory Systems*, American Elsevier Publishing Company, Inc., New York, NY, 1976, p. xii.

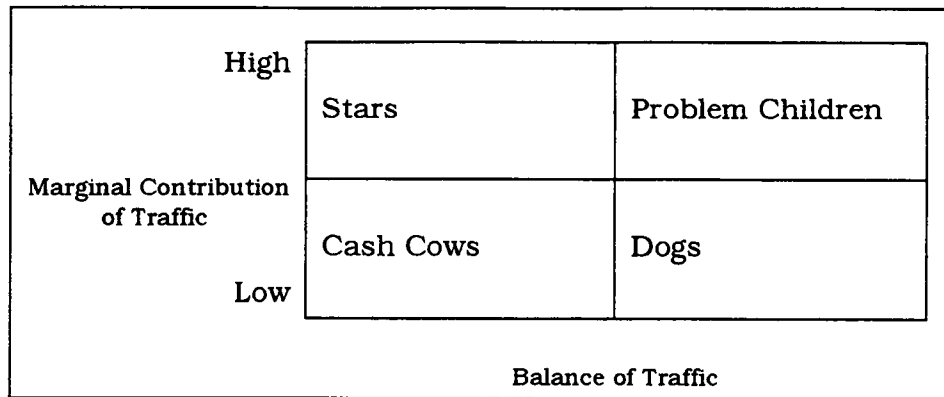


FIGURE 10

Transportation Industry Segmented Markets

Source: Ray A. Mundy, "Managing and Evaluating Carrier Pricing," *Logistics Resource Forum*, #3, Published by Logistics Resources, Inc., Cleveland, OH, September, 1983, p. 127.

setting and by focusing marketing efforts. The diagram helps to distinguish among customers and market segments for price setting purposes.

Mundy suggests that this model should be used to assist in the evaluation of geographic market segments by their degree of balance of traffic. In particular, "stars" are the most profitable market segments, enjoying a high degree of balance and a high contribution to margin, "dogs" are market segments that should be immediately renegotiated or eliminated, "cash cows" are market segments with a high balance of traffic but a low contribution to margin, and "problem children" are market segments with a potential for margin contribution but that exhibit a low balance of traffic. Marketing efforts should be focused most profitably on "problem children."⁶⁹

In spite of the model's appeal, these ideas have proven difficult to implement due to the difficulty in identifying geographic markets designated as a "problem child." Clearly, a DPDST that could classify market segments accord-

69. Mundy, p. 128.

ing to this or some competing model could aid both strategic and tactical marketing efforts.

Contributing Technologies

As mentioned earlier in part II, several technical areas will provide the necessary tools in order to develop the DPDST as described. Several of these, along with their major contributions to the research will be discussed in the following sub-sections.

Activity Based Costing

Activity based costing (ABC) was introduced by Robert S. Kaplan into the manufacturing industry over a decade ago.⁷⁰ It is "a cost allocation methodology that focuses on improving how a firm allocates overhead, selling, and administrative costs."⁷¹ The question of how to allocate such costs affects profitability. The decision of how these costs are allocated will affect the reported profitability of the company's traffic as well as the prices that must be charged to make a profit, and will influence the overall competitiveness of the carrier's services.⁷²

"Unfortunately, in too many cases, product prices are established based on flawed or misleading product cost data provided by the firm's accounting function. Misconceptions about product costs can result in the wrong products being promoted, price discounts being offered on products that are actually losing

70. See: Richard Troxel and Milan Weber, "The Evolution of Activity-Based Costing," *Journal of Cost Management*, 4, no. 1, Spring, 1991, pp. 14-22. As cited in Campbell, p. 76.

71. Campbell, p. 6.

72. Temple, et. al., p. 83.

money, and market share being lost by maintaining inappropriately high prices (and margins) on other products. The firm may know its total cost structure, but methods and procedures used to trace costs to products or identify supposed cause-and-effect relationships between costs and products may utterly fail to represent the true cost of supporting the existence, manufacture, and distribution of individual products."⁷³

ABC takes overhead (and similar) costs and allocates these costs on the basis of how they are generated. For example, costs associated with non-revenue generating miles in a TL firm might be allocated on a per transaction basis (where each transaction would be allocated an equal amount of the costs associated with total, annual non-revenue miles incurred by the TL firm). ABC would suggest that the costs could be more precisely and "fairly" allocated based on the actual number of non-revenue generating miles associated with a particular geographic market segment. ABC, therefore, "makes a significant contribution towards the understanding of resource consumption" by allocating overhead (or common or fixed costs) on causes or motivations that drive such costs.⁷⁴ By using ABC, "[m]anagement can obtain a better allocation of indirect costs, and thus a better understanding of profitability."⁷⁵

It will be noted that in the above example, non-revenue generating miles served as a basis for cost measurement. In general, ABC identifies cost drivers and measures costs based upon cost-driver levels.⁷⁶ For example, non-revenue generating miles, revenue generating miles, non-revenue generating time, revenue generating time, fuel prices, fuel tax rates, etc. could all be considered cost

73. Campbell, p. 1.

74. Campbell, p. 7.

75. Raue, p. 19.

76. Mundy, et. al., 1994, p. 9-10.

drivers.⁷⁷ The cost measurement of a transaction is based upon the "resource consumption" associated with each cost driver. For instance as linehaul distance of a shipment increases or decreases, the costs associated with the revenue generating miles of the shipment increase or decrease proportionately.

The proponents of ABC claim that it possesses the advantage of assigning common costs more fairly and with greater detail than traditional accounting methods. Besides allowing prices to be set more appropriately than would otherwise be possible, ABC makes the identification of unprofitable offerings versus profitable offerings much less complicated. "The allocation of costs to products is needed to determine whether current selling prices are adequate. The knowledge of what products are winners and losers and how best to use scarce resources should not be lost in the process of cost allocation."⁷⁸

Because of its ability to effectively allocate costs, ABC has particular relevance in the transportation industry where cost drivers have frequent fluctuations. The use of ABC in the TL industry has received attention recently, but few carriers utilize costing systems that implement ABC principles.⁷⁹ This creates an opportunity for companies to gain competitive advantage by using these costing methods. For example, these methods could facilitate the identification of geographic market segments that need special attention ("problem children" as discussed on page 60).

In adapting ABC techniques to trucking, three main categories of cost drivers have been identified: mileage-based, time-based, and transaction-based.⁸⁰ The mileage-based cost drivers can be further refined to revenue generating

77. Raue, p. 19.

78. Campbell, p. 253.

79. Raue, p. 18.

80. Raue, p. 19.

mile-based cost drivers and non-revenue generating mile-based cost drivers. Similarly, time-based cost drivers can be further refined to revenue generating time-based cost drivers and non-revenue generating time-based cost drivers.

If a TL firm were to implement these measurements, they would need to measure revenue generating miles and time for each transaction as well as non-revenue generating miles and time for each transaction. (This would require that data be collected appropriately for this objective.) This degree of attention to detail should be contrasted with the more traditional mindset where debates exist as to whether costs should be allocated on a per shipment basis or a per ton-mile basis.⁸¹

Perhaps the most difficult part of implementing ABC in the TL industry involves measuring non-revenue generating activity levels. Some empty (non-revenue generating) miles can be considered assignable. The types of empty miles that can be easily considered assignable are:

- "Movements into or out of areas that are chronically imbalanced because they have a heavy inbound or outbound freight flow
- Positioning dispatches that connect a TL delivery with its next pickup
- Intraterritory empty dispatches that may reflect day-of-the-week traffic shifts and flows, and other interterritory imbalances
- Interterritory empty dispatches that reflect the imbalances between territories."⁸²

However, other non-revenue generating miles demand management policy decisions regarding allocation. This is due to the many ways of measuring these activities. For example, should the non-revenue generating miles associated with a transaction be defined as the number of miles from delivery to the next pick-

81. Gagne, Robert J., "On the Relevant Elasticity Estimates for Cost Structure Analyses of the Trucking Industry," *Review of Economics and Statistics*, Vol. 72, Issue 1, Feb., 1990, pp. 160-164.

82. Temple, et al., p. 89.

up, or as the number of miles from the previous delivery to pick-up, or some other scheme?

This concept has received attention for years. Some of the important issues regarding empty (non-revenue generating) miles are:

- "What caused the empties?"
- Who should bear the cost of the empties?
- How should carriers deal with empties?"⁸³

Classically, empty miles, or non-revenue generating miles, have been allocated using four different approaches:

- "Post-deadhead—In this approach all empty miles incurred after the load has been delivered are assigned to the original loaded headhaul.
- Pre-deadhead—This approach assigns to the load all empty miles incurred prior to pickup.
- Combination—Fifty percent of the post- and pre-deadhead miles are assigned to the load, as a combination factor.
- System Overhead Cost—The cost of running empty miles is treated as an overhead or system expense. Empty mile costs are assigned on the basis of a fixed charge per load per mile. The costs involved with running empty miles are absorbed equally by all users of the service."⁸⁴

One of the contributions that ABC can bring to this assignment of costs associated with non-revenue generating miles or time is its use of disaggregated, automatically collected, historical data to measure these costs based on a given geographic market segment. Figure 11 illustrates how non-revenue generating miles could be calculated using ABC methods for a given geographic market segment.

83. Temple, et al., p. 87.

84. Ernst & Whinney, pp. 88-89.

Situation: The carrier's cost of operating a linehaul trailer, either loaded or empty, is \$1.00 per mile. No system empties have been incurred and the carrier has 15 loads moving 500 miles from B to A (the headhaul) with only 10 loads returning to B (the backhaul).

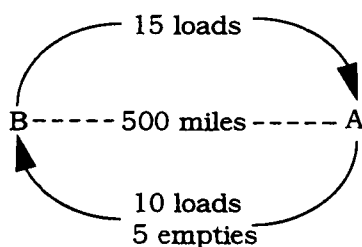


FIGURE 11

Non-Revenue Activity

Adapted from Temple, Barker, & Sloane, Inc., *Creating Profitability: The Sales and Marketing Challenge*, Sales and Marketing Council, American Trucking Association, Inc., 1985, p. 94.

In the above situation, the B to A market incurs costs of returning empty one third of the times. ABC might suggest that the cost of operating from B to A costs more (\$1.33 per mile) than operating from A to B (\$1.00 per mile). The actual assignment would depend on how management chose to define the activity. For example, one definition of an activity could be operating a linehaul trailer from an origin to the next origin. However, it could also be defined as operating a linehaul trailer from origin to destination. This example emphasizes that although even ABC methods use somewhat arbitrary (although logical) allocation schemes, they are still much more refined than traditional costing methods.

Costing Systems

The implementation of ABC techniques allows some latitude. For example, cost measurements can be automated or they can be calculated by hand.

Table 1 lists some of the classical costing systems along with some of their inherent advantages and disadvantages.

The costing system that this dissertation proposes to embed in the DPDST would be a hybrid of several of the classical systems, borrowing from the strengths of several of them. In particular, the system will be a stand-alone system but will include simple links to on-line data so that the listed disadvantages do not apply to the degree that they normally would. Although the system being developed will not be a true integrated system, it will share more of the attributes normally associated with such systems than with traditional stand-alone systems. The system also will be an automated system. However, it should include much of the flexibility normally associated with manual systems. Again, the objective is to bridge the two classical systems and to include the most desirable attributes from both automated and manual costing systems. Finally, the DPDST will be packaged but will include the flexibility to be customized to the carrier's individual operations so that it behaves more like a customized costing system than a traditional packaged costing system.

TABLE 1**The Advantages and Disadvantages of Alternate Costing Systems^a**

Various Systems	Advantages	Disadvantages
Stand-alone	• Inexpensive to develop • Easy and fast to install • Very flexible in ability to analyze particular pieces of traffic	• May not agree with other systems • Requires data entry or linkage programs • May not facilitate looking at all traffic • Basically forces reactive management
Integrated	• Agrees with other systems • Able to see all traffic at once • Facilitates action-oriented management • Able to pinpoint problem areas • Minimizes data reentry	• Expensive to design, program, and install • Likely to cause changes in other supporting systems • Requires significant support
Manual	• Inexpensive to develop • Can be very flexible	• Slow and error prone • Able to do only one segment of traffic at a time • Difficult to track history • High unit cost per analysis
Automated	• Fast turnaround • Accurate (error free) • Permits development of consistent history • Lower unit cost per analysis	• Requires hardware and software • Must have technical and user support • Requires accurate file maintenance • Higher up-front costs
Packaged	• Inexpensive to buy • Easy to install • Generally doesn't require in-house support	• May not reflect carrier's operations • May not reflect carrier's costs
Customized	• Reflects carrier's operations, practices, and philosophies • Uses carrier's costs and productivity levels	• Expensive to develop or customize • Time consuming to install

a) Adapted from: Temple, et. al., p. 29.

Economic Value Added

The term economic value added (EVA) was coined by G. Bennett Stewart and Joel M. Stern as a management concept to help businesses improve profitability.⁸⁵ However, its views embody ideas, as mentioned in part I, dating back to the mid-1800's with Marshall and his contemporaries, who considered profits to be the return on investment to stockholders. Defining profits in this manner requires that measurements of profitability use cost calculations that contain all direct and indirect costs, including capital costs and taxes, and that capital costs include a required return to investors.⁸⁶ This inclusion of capital costs in profitability analysis aids management in project evaluation. This is important since a firm that does not earn profits in excess of investor's required return will lose the ability to tap capital markets.

EVA has been found useful in addressing many distinct problems in addition to project evaluation. For example, Quaker Oats has recently instituted strategic changes based upon EVA calculations. This has led to rescheduled production to require fewer warehouses with resulting decreased capital costs and increased profitability.⁸⁷ Additionally, EVA is gaining popularity as a means of calculating executive performance, as performance-based executive compensation packages become increasingly more common.⁸⁸

The use of EVA by firms to secure an adequate return for investors has received a great deal of attention due to the apparent cause and effect between

85. Rutledge, p. 148

86. Marshall, pp. 61-62. Note that this contrasts with generally accepted accounting principles which deduct only the interest on debt from profits, not the cost of equity capital.

See also: Rutledge, p. 148.

87. Tully, p. 48.

its use and the dramatic increase in stock prices of corporations that have implemented this technology.⁸⁹ This increase in stock prices is naturally explained as seen in the following example of CSX.

In 1988 CSX found that its new intermodal business venture was losing 70 million dollars when EVA calculations, rather than previous measures of profitability, were considered. The venture was given five years to cover its capital costs or the business unit would be sold. By 1992, CSX's intermodal division's EVA was 10 million dollars and was increasing rapidly. This contributed to CSX's stock price rising from \$28 when EVA was introduced at CSX to \$75 in 1993.⁹⁰

The use of EVA is a form of self-fulfilling prophecy with regards to profitability. If a business unit or market does not cover a fully allocated cost (including capital costs), the business unit should be sold or abandoned. Over time, this practice will have the effect of removing all "unprofitable" business offerings. All existing business units and projects should be evaluated on this basis. The abandonment of all business units and projects that do not provide an adequate return suggests that the remaining business units should cover investors' required return. This should influence stock prices positively. Practice shows that this is in fact the case.⁹¹

88. Tully, p. 50.

See Also: Stewart, G Bennett III, "Reform Your Governance From Within," *Directors and Boards*, Spring, 1993, pp. 48-54.

See also: Stern, Joel M., "One Way to Build Value in Your Firm, a'la Executive Compensation," *Financial Executive*, November/December, 1990, pp. 51-54.

See also: Willigan, Geraldine E., "The Value-Adding CFO: an Interview with Disney's Gary Wilson," *Harvard Business Review*, January-February, 1990, pp. 85-93.

89. Tully, pp. 38-41.

90. Tully, p. 39-40.

91. Tully, pp. 40-44.

The pricing suggestion method proposed by this research will extend the common use of EVA from the strategic to the tactical arena by dynamically calculating fully allocated transaction costs. The inclusion of capital costs and taxes in measurements at the transaction level allows costs to provide a suggested minimal transaction price. The inclusion of this philosophy and technology will provide the pricing system with necessary profit structures. EVA will be utilized and will be instrumental in both the theoretical model and the software prototype that will be developed.

Information Engineering

In order to incorporate the above mentioned technologies and theories (ABC, costing, and EVA) into an accurate and useful decision-support tool, up-to-date, accurate data is required. This is best accomplished, as suggested by Hammer and Champy, through the use of information engineering methodologies.⁹² These methodologies balance high system performance with flexibility in the management of the vast amounts of data frequently collected⁹³ and are critical to the success of a dynamic decision-support tool.

A dynamic decision-support tool requires pertinent data to be identified, collected, and organized properly. The organization of the data must be such that as a business transaction occurs, the data from the transaction is fed automatically into the decision-support tool. Finally, the database design for this

92. Hammer, Michael and James Champy, *Reengineering the Corporation, A Manifesto for Business Revolution*, Harper Business, New York, 1993, pp. 95-96.

93. Flaatten, Per O., Donald J. McCubbrey, P. Declan O'Riordan, and Keith Burgess, *Foundations of Business Systems*, The Dryden Press, Chicago, 1989, p. 337.

automatically collected data must be flexible so that changes can be made easily to the information system as requirements and needs evolve.

Methodologies that efficiently collect and organize data have been developed and studied extensively. James Martin is the most prolific writer on this topic having introduced the concepts of modern information system design.⁹⁴ By utilizing the methodologies developed by Martin, it is possible to create an information system that involves top-level management in the planning process.⁹⁵ This should give greater utility to the dynamic decision-support tool since it will allow top level management to influence the design of the system to assure that corporate objectives are met.

In order to create a decision-support tool that dynamically suggests optimal pricing there must be access to a wide variety of data. For example, data must be available on capital costs, individual transactions, linehaul distances, up-to-the-minute fuel prices and tax rates, etc. Information engineering research shows the difficulties with storing large amounts of such unrelated data in one large table. However, these difficulties are overcome by organizing the data into separate tables, each properly organized and related with *entity relationship diagrams*⁹⁶ and appropriately *normalized*.⁹⁷

Another relevant concern in the creation of a dynamic decision-support tool is that the necessary number of data summaries and computations will place demands on the system that are much greater than those required of traditional

94. See for example: Martin and Finkelstein, 1979, and other earlier works.

95. Martin, James, *Strategic Data-Planning Methodologies*, Englewood Cliffs, New Jersey, Prentice Hall, 1982.

96. Flaatten, pp. 343-390.

97. There are differing degrees of normalization. For example, the first level is known as first normal form (1NF) — "[a] relation is in first normal form (1NF) if it contains no repeating groups." Flaatten, p. 377.

information systems. It will therefore be important to organize the data carefully so as to facilitate real-time analyses. In some instances, it may, in fact, be advisable to use summary tables. For example, time-based transaction data might be summarized and updated incrementally to speed up calculation time.⁹⁸ This process is sometimes referred to as "rolling up data."⁹⁹

The collection, organization, calculations, and summaries of the data should reveal existing and changing business patterns, i.e., should extract information from the data. This transformation of data into information requires dynamic statistical analyses to identify patterns as they occur. The next subsection introduces statistical methods that facilitate these dynamic analyses.

Information Theoretic Statistics

In order to use automatically collected data to improve decision making, statistical analyses of the data is necessary. To be truly useful, these analyses must be dynamic, giving results in real-time. Traditional analytical methods are often cumbersome, are sometimes confusing, and at best are time consuming, making real-time data analyses difficult or even impossible. New statistical tools designed for dynamic data analyses are needed to replace existing methods. These new statistical tools must possess several attributes. Among other things, they must possess the ability to be embedded in automated decision-support systems and must identify changing business patterns as they occur. Further, they must be easily understood so that they can be a tool in the hands of non-

98. Flaatten, p. 344.

99. Jennings, Roger, *Database Developer's Guide with Visual Basic™ 3*, Sams Publishing, Indianapolis, Indiana, 1994, pp. 348–349.

quantitative front-line personnel, and they must improve the accuracy of statistical model identification and forecasts made by currently available tools.

In 1973, Hirotugu Akaike introduced "Akaike's Information Criterion" (AIC).¹⁰⁰ The field of study that has developed from Akaike's discovery is called "Information Theoretic Statistics" (ITS). ITS, by its very theoretical framework, has the attributes mentioned above. In fact, ITS can be automated to analyze automatically collected data in a wide variety of situations, yielding quicker and more accurate¹⁰¹ results than is possible with traditional methods. Because of this, many dynamic forecasting systems currently implement some form of ITS.¹⁰²

Part of the power of ITS comes from its ability to compare large numbers of competing statistical models simultaneously by assigning to each a comparable scalar value, where this scalar value is a ranking or score that is independent of units of measurement. In assigning these rankings, Akaike extended the theories of L. Boltzmann (generalized entropy, 1877)¹⁰³ and of S. Kullback and R. A.

100. Akaike, 1973, pp. 267-281.

101. The word "accurate" is used to indicate appropriate statistical model identification or forecasting.

102. For example, see Jiang, Jiunn-Yih, *The Decision and Testing of a Model-Based System for Real-Time Marketing Forecasts*, Ph.D. Dissertation submitted to University of Cincinnati, 1992.

See also: Gutwein, Barry Joe, *Analysis and Prediction of Regional Irrigation Water Demand (Evapotranspiration)*, Dissertation for Colorado State University, 1991, Volume 52/09-B of Dissertation Abstracts International, p. 4851.

See also: Nakamura, Hideo, "Statistical Identification and Optimal Control of Thermal Power Plants," *Analysis of Statistical Information*, Symposium on the Analysis of Statistical Information, The Institute of Statistical Mathematics, Tokyo, December 5-8, 1989, Paper No. 21, pp. 337-362.

See also: Reifschneider, David Leon, *The Forecasting of the Distribution of Weekly Peak Electricity Demand and its Application to Planned Outage Scheduling*, Ph.D. Dissertation submitted to the University of Wisconsin—Madison, 1983.

103. Boltzman, L., "Über die Beziehung zwischen dem zweitin Hauptsatze der mechanischen Wärmetheorie und der Wahrscheinlichkeitsrechnung respective den Sätzen über das Wärmegleichgewicht." *Wiener Berichte*, 76, 1877, pp. 373-435.

Liebler (negentropy or information quantity, 1951)¹⁰⁴ to balance model complexity with "goodness-of-fit" (this balancing—or the search for a simple model—is known as the "principle of parsimony").¹⁰⁵ These two characteristics—comparability and parsimony—are critical attributes not found in more traditional statistical methods.

The importance of the first attribute—that all models may be compared—overcomes a major shortcoming found in many Multiple Comparison Procedures (MCP's) such as ANOVA or MANOVA, namely, the lack of transitivity. In particular, using traditional statistics, it is possible to compare three competing models, A, B, and C, and to find that model A should be preferred over model B, that model B should be preferred over model C, and that model C should be preferred over model A. When this situation occurs, it is not clear which model should be preferred, A, B, or C, as illustrated in figure 12.

ITS overcomes this shortcoming by assigning a scalar value or score to each model. These scores indicate a ranking among the competing models where the lower the score, the better the alternative. This allows an identification of the most appropriate model by an ordering of the AIC scores.¹⁰⁶ For instance, using the above example of models A, B, and C, suppose that model A is assigned an AIC score of 67, model B an AIC score of 77, and model C an AIC score of 87. It then becomes clear that model A is preferred to either model B or C, and model B is preferred over model C, as figure 12 illustrates.¹⁰⁷

104. Kullback, S. and R. A. Leibler, "On Information and Sufficiency," *Annals of Mathematical Statistics*, 22, 1951, pp. 79–86.

105. Parsimony is also known as "Ocam's Razor." See: Bozdogan, Hamparsum, *STAT-683: Statistical Modeling, Text, Statistical Modeling and Model Evaluation: A New Information Theoretic Approach*, Graphic Creations, Knoxville, TN, 1990.

See also: Bozdogan, Hamparsum, "Model Selection and Akaike's Information Criterion (AIC): The General Theory and Its Analytical Extensions," *Psychometrika*, Vol. 52, No. 3, 1987, pp. 345–370.

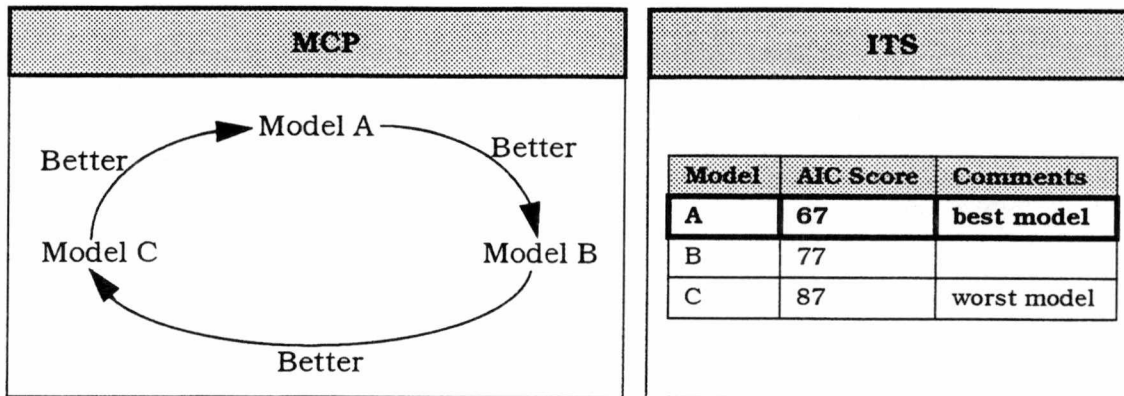


FIGURE 12 Lack of Transitivity in Traditional MCP Versus Complete Comparability with ITS (using AIC Scoring Criterion)

The importance of the second attribute—that model complexity is balanced with “goodness-of-fit”—is illustrated in the following example. Consider three competing linear regression models, model A based upon the variable X, model B based upon the variables X and Y, and model C based upon the variables X, Y, and Z. The issue is to select the most appropriate model from the three under consideration. A common method of selection compares an R^2 score for each model. By design, the R^2 score will increase with complexity and will suggest the “full model” (that is, the model that utilizes all variables).¹⁰⁸ On the other hand,

106. Many distinct ITS scoring criteria exist and some actually compete with each other. (For a comparison of several of these see: Bozdogan, Hamparsum, “On the Information-Based Measure of Covariance Complexity and its Application to the Evaluation of Multivariate Linear Models,” *Communications in Statistics, Part A: Theory and Methods*, Marcel Dekker, Inc. New York, 19 (1), 1990, pp. 267, 269.) A common point of comparison for many of these papers is the original ITS scoring criterion, namely Akaike’s Information Criterion (AIC). Many other ITS scoring methods are improvements on Akaike’s original criterion, such as Hamparsum Bozdogan’s ICOMP criterion. Nonetheless, the original AIC criterion yields results that far surpass traditional methods in correct model identification and AIC yields virtually identical results with other ITS criteria when used with large sample sizes. (See: Bozdogan, *STAT-683*, 1990).

107. Bozdogan, Hamparsum, “Multi-Sample Cluster Analysis as an Alternative to Multiple Comparison Procedures,” *Bulletin of Information and Cybernetics Research Association of Statistical Sciences*, Vol. 22, No. 1-2, 1986, pp. 100-101.

ITS scoring methods such as AIC will find the optimal model that balances the competing concepts of goodness-of-fit and lack of complexity or "parsimony."¹⁰⁹ In particular, suppose that A has an R^2 score of .999 and an AIC score of 67, B an R^2 score of .9999 and an AIC score of 77, and C an R^2 score of .99999 and an AIC score of 87. Clearly, the contribution of the variables Y and Z are negligible. The R^2 criterion is inadequate to determine this whereas AIC properly identifies the correct model.¹¹⁰ ITS' advantage of balancing goodness-of-fit against model complexity extends beyond linear regression to virtually all traditional statistical methods.

Since ITS possesses these attributes, it has the ability to answer a different, and often more useful, set of questions than traditional statistical techniques. For example, traditional hypothesis testing answers the questions:

1. "Is model A better than B?"
2. "Is model A the same as model B?"
3. "Is model A worse than model B?"

while ITS answers a different question:

1. "Which model is best?"

This distinction puts ITS in a position to make a great contribution to dynamic decision-making since many research questions are most naturally posed as "which of these many alternatives is best?" For example, if a TL carrier

108. With respect to linear regression, Akaike's Information Criterion (AIC)—an ITS scoring criterion—measures complexity as the number of parameters or exogenous variables. See Bozdogan, Hamparsum, "On the Information-Based Measure....," 1990, pp. 224.

109. Bozdogan, 1987, pp. 345-370.

110. For a discussion of R^2 in multiple regression models, see: Myers, Raymond H., *Classical and Modern Regression with Applications, Second Edition*, PWS-Kent Publishing Company, Boston, 1990, pp. 95-96.

For a discussion of ITS in multiple regression, see: Bozdogan, 1990, pp. 221-278.

contemplates serving a particular market segment and wishes to determine a model to describe the line haul time required to make this run, the model could include a wide variety of variables, including linehaul distance, the time of day of pickup, the number of stops, whether or not the truck is routed through a major metropolitan area, the time of day of delivery, and so on. In order to develop the best model, decisions must be made as to which variables are significant enough to include, and which only add confusion or complexity. ITS is able to answer this question quickly, directly, and elegantly.

The application of ITS just mentioned is known as optimal model selection. Another common application of ITS is multi-cluster analysis.¹¹¹ This was alluded to above with the mention of MCP's such as ANOVA and MANOVA. Multi-cluster analysis allows data to be aggregated or disaggregated optimally. For example, ITS could address the question: "How should the time periods—12 am–8 am, 8 am–4 pm, 4 pm–12 am—be grouped or 'clustered' together?" Table 2 below shows all possible clusterings and illustrates how ITS identifies the best clustering or degree of disaggregation of data.

TABLE 2

Multi Cluster Analysis

Model	AIC Score
{12a–8a}, {8a–4p}, {4p–12a}	123.2
{12a–8a, 8a–4p}, {4p–12a}	138.5
{8a–4p}, {12a–8a, 4p–12a}	102.4
{12a–8a}, {8a–4p, 4p–12a}	95.1
{12a–8a, 8a–4p, 4p–12a}	143.2

111. Bozdogan, 1986, pp. 95–129.

Table 2 indicates that all records with PU times from 8 am to 12 am should be aggregated together and the records with PU times from 12 am to 8 am should be treated differently. Thus the data should be disaggregated by PU time with those records with PU times before 8 am being treated differently than those with PU times after 8 am.

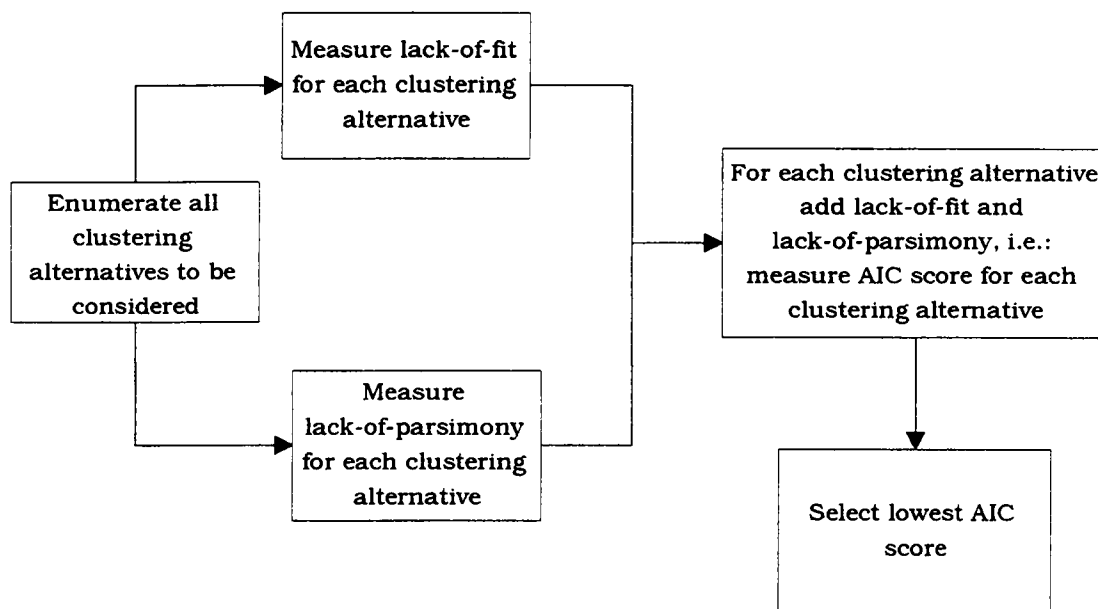
By carefully taking advantage of the power of ITS, multi-sample cluster analysis can be combined with model selection criteria to find optimal models. This allows both the use of optimal models and the use of data that is aggregated or disaggregated optimally. Figure 13 describes how this is accomplished.

Another advantage of ITS is the ease with which it can be used to improve computer-based, decision-support tools.¹¹² Using currently available computer technologies, ITS analyses can be programmed to repeat analyses over and over again virtually instantaneously and without user interpretation or interaction as new data is collected. This allows a computer system to make optimal model selections automatically and in real-time to aid in dynamic decision making.

To appreciate this advantage, consider the following example. Suppose that a TL firm wishes to measure the costs of serving individual geographic market segments dynamically. Suppose further that the firm has a complicated cost measurement device that can measure each cost quite accurately. However, the time required to complete the measurement precludes the measurement device from being used dynamically. The identification of an accurate costing model that would yield accurate and quick results could provide a solution to the above problem.

¹¹². Many comparisons of the advantages of ITS over traditional statistical methods with regards to accuracy (correct model identification) can be found in: Bozdogan, Hamparsum, *STAT-683*, 1990.

ITS Multi-Cluster Analysis



ITS Model Selection Analysis

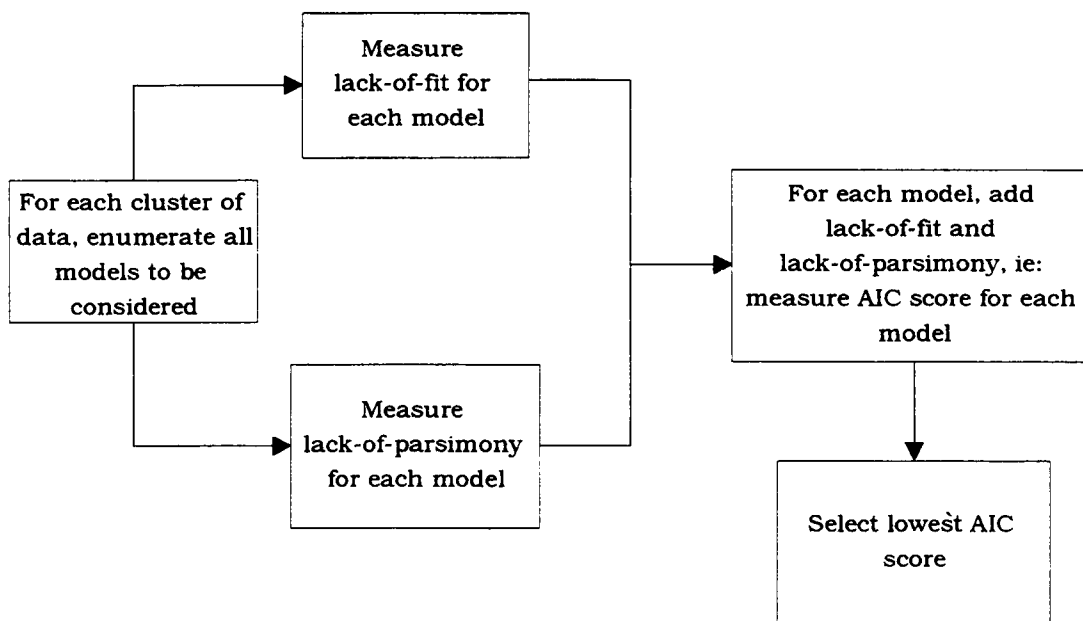


FIGURE 13 Multi-Cluster Analysis and Model Selection Criterion

Most costs in a TL firm can be considered linear functions of the following cost drivers: 1) linehaul distance, 2) linehaul time, 3) non-revenue distance, and 4) non-revenue time. ITS can be used to identify an optimal linear regression model, where costs are regressed against these cost drivers. Since the measurement device is so time-consuming, a random sample of representative market segments can be used to create the optimal model.

If AIC is used to identify the optimal regression model, it will calculate an AIC score for each competing model, and will identify best model from the list of all competing models. Supposing that all possible subsets of cost drivers are used to create the competing models, Table 3 shows how this might look.

TABLE 3

Linear Regression Results for Competing Models

Model	ITS Score
X_0	93.695
X_0X_1	92.568
X_0X_2	95.285
X_0X_3	90.991
X_0X_4	78.742
$X_0X_1X_2$	91.675
$X_0X_1X_3$	92.905
$X_0X_1X_4$	77.263
$X_0X_2X_3$	91.024
$X_0X_2X_4$	80.035
$X_0X_3X_4$	52.207
$X_0X_1X_2X_3$	92.115
$X_0X_1X_2X_4$	79.190
$X_0X_1X_3X_4$	47.084
$X_0X_2X_3X_4$	44.929
$X_0X_1X_2X_3X_4$	-18.836

Notes: X_0 — constant term
 X_1 — linehaul distance
 X_2 — linehaul time
 X_3 — non-revenue distance
 X_4 — non-revenue time

Table 3 shows that the full model using the variables $X_0X_1X_2X_3X_4$ should be used. This “best” linear regression model is used to estimate the cost of serving all market segments in real time.

As this example illustrates, many of the concerns discussed at the beginning of this sub-section (see page 74) can be overcome. Additionally, preliminary research shows that by using commonly understood numerical techniques, ITS can, in fact, be embedded effectively in a dynamic decision-support tool, particularly to develop dynamic forecasts and pricing suggestions.¹¹³ The next sub-section discusses this in more detail.

Numerical Mathematics

In spite of the advances in information engineering, forecasting, and ITS, the large number of calculations necessary to implement a DPDST introduces two concerns. First, calculation time might prevent dynamic analyses. Second, round-off error might invalidate any calculated results. These issues are classical and have been studied for decades. Both of the concerns are adequately treated in introductory numerical mathematics textbooks.

The example given above on clustering time periods (see page 79) can illustrate the problems with calculation speed. Suppose that in this example, the original clusters were defined by the shipment PU times as: cluster 1) 12 am–3 am, cluster 2) 3 am–6 am, cluster 3) 6 am–9 am, ..., and cluster 8) 9 pm–12 am. Naively, if an optimal clustering of data is sought, we should want to consider all possible clusterings. The optimal clustering could then be identified and used to optimally disaggregate the data. Unfortunately, the number of clustering options

113. Unpublished, personal research, 1994.

to consider in this scenario is 4,140.¹¹⁴ If each cluster of data were considered separately, optimal model selection procedures would be used distinctly for each cluster. For example, if there are 10 variables (such as linehaul distance, number of stops, etc.) being considered in a linear regression model, there are $(2^{10} - 1)$ or 1023 models to compare for each cluster. This would mean that as many as $(1,023 \times 8) + 4,140 = 12,324$ distinct models would have to be compared. The calculation of an ITS score for each model is potentially quite time consuming. The combined time required for all the models under consideration could prevent the system from being interactive if implemented unwisely.

Of further concern, the amount of roundoff error in these calculations could invalidate any results if not treated properly. This is most likely to occur when the data collected gives rise to an ill-conditioned covariance matrix.¹¹⁵

Both of these concerns can be resolved with classical techniques such as an LU decomposition using Crout's method with partial pivoting (interchange of rows). This is a highly efficient method that directly addresses the speed issue. The partial pivoting addresses the concern of the potential ill-condition of the covariance matrix.¹¹⁶ Combinatorial and heuristic methods can further speed up the calculations.^{117, 118}

114. In general, the number of combinatorial options is described by Sterling's Number of the Second Kind. Bozdogan, 1986, p. 104.

115. Kreyszig, Erwin, *Advanced Engineering Mathematics*, John Wiley and Sons, Inc., New York, 1972, p. 679.

116. Press, William H., Brian P. Flannery, Saul A. Teukolsky, and William T. Vetterling, *Numerical Recipes in Pascal, The Art of Scientific Computing*, Cambridge University Press, Cambridge, 1989, pp. 39-47.

117. Bozdogan, Hamparsum, Di Li, and S. L. Sclove, "Information Theoretic Combinatorial Clustering of Variables," working paper, 1989.

118. An example of a heuristic method that can dramatically speed up calculations is: "The Splitting Algorithm for Multi-stage Cluster Analysis," Bozdogan, 1986, pp. 106-107.

Using these techniques, the concerns addressed can be overcome. Benchmarks show that the calculations needed to perform ITS analyses can be completed in real-time.¹¹⁹ Thus, using commonly understood numerical techniques, ITS can be operationalized in a DPDST.

Forecasting

By accurately analyzing historical data, patterns can be seen that enable forecasting of future business events. For instance, as mentioned on page 82, one of the purposes of the optimal statistical model creation in this study is to forecast linehaul time for new markets. Other measurements must be forecast as well, such as non-revenue generating distance. Ideally, this will be done using optimally disaggregated data.

As discussed by Bolt in his text on forecasting, over the life cycle of any given product or service, several different techniques should be used to obtain appropriate forecasts. For instance, marketing research that does not depend on historical data is the only appropriate forecast at the beginning of the life-cycle of any given product. As time progresses, exponential smoothing may become appropriate, and eventually segmentation analysis may become more appropriate.¹²⁰ The technique that gives the best forecast at any given point is affected by the nonstationarity of historical data as well as other factors.¹²¹ ITS can make adjustments for such influences and dynamically identify the most appro-

119. Unpublished, personal research, 1994.

120. Bolt, Gordon J., *Marketing and Sales Forecasting, Second Edition*, Franklin Watts, Inc., New York, NY, 1988, p. 331.

121. Miller, C. M., R. T. Clemen, and R. L. Winkler, "The Effect of Nonstationarity on Combined Forecasts," *International Journal of Forecasting*, 1992, Vol. 7, No. 4, Mar., pp. 515-529.

priate forecasting technique by choosing the optimal forecasting model at any given point. As illustrated in one recent study, the value that ITS brings to forecasting is, in part, that it can dynamically update the model selection, allowing previous forecasts to be combined with current forecasts to more accurately predict future sales or demand.¹²² This approach shares characteristics with a Bayesian statistical approach where previous beliefs and knowledge influence present and future beliefs. This constant recalculation of the forecast, using optimal model selection, can maintain and even improve, with time, the accuracy and usefulness forecasting activities.

To choose the best model at any point in time, the degree to which the data should be segmented or disaggregated must be balanced with the degree that the data should be aggregated. An optimal model selection process can identify this optimal degree of data segmentation and aggregation.¹²³ ITS can accomplish this identification by fitting optimal models to the distinct data sets formed as a result of distinct levels of data segmentation and aggregation, then choosing the model that best fits the underlying data set.

For example, the definition of a geographic market segment could be defined using 5-, 3-, 2-, or 1-digit zip code pairs. An optimal model correlating several attributes to linehaul distance and time or to non-revenue generating distance and time could be identified for each distinct potential market segment definition. Then, the market segment definition that is associated with the best model should be used.

122. Reifschneider, pp. 1-359.

123. Personal conversations with Dr. Hamparsum Bozdogan, 1994, 1995.
See also: discussion of ITS beginning on page 74.

Notice that such forecasts must be quantified so that they can be integrated into a DPDST. Quantitative forecasting methods can be grouped into two kinds: times series and causal.¹²⁴ Time series analysis is the obvious mechanism to implement in a dynamic decision-support tool based upon historical data. However, problems exist with time series forecasting that must be addressed. These problems, as defined by Kotler, are as follows: "[1] too few observations, [2] too much correlation among the independent variables, [3] violation of normal distribution assumptions, [4] two-way causation, and [5] emergence of new variables not accounted for."¹²⁵

Fortunately, the use of ITS directly addresses and removes most of these concerns. A great deal of literature has appeared showing the value of ITS in time-series analysis.¹²⁶ For example, the first concern of an insufficient number of observations can be addressed with an optimal model selection that compares models based upon differing degrees of data aggregation, as discussed above. The solution to the second concern is at the heart of ITS. The optimal model selection eliminates as much covariance from the model as could be justified. The other concerns can be addressed similarly through the use of ITS, etc.¹²⁷ With these improvements to traditional time series analyses, dynamic forecasting becomes attainable. This will be critical to the success of this project.

124. O'Donovan, Thomas M., *Short Term Forecasting—An Introduction to the Box-Jenkins Approach*, John Wiley & Sons, Chichester, 1983, p. 3.

125. Kotler, p. 275.

126. See for example: Akaike, H., "Likelihood of a Time-Series Model," *Statistician*, 1978, Vol. 27, No. 3-4, pp. 217-235.

127. Bozdogan, Hamparsum, "Multi-Sample Cluster Analysis as an Alternative to Tests of Homogeneity and Multiple Comparison Procedures," as published in *Stats 671: Informational Complexity and Multivariate Statistical Modeling*, H. Bozdogan (editor), The University of Tennessee, Knoxville, 1990, Graphic Creations, Knoxville, Fall, 1991, p. 1-39.

Summary

By combining all the philosophies, theories, and technical areas mentioned herein, the tools are in place to achieve the purpose of this study. None of the tools plays such a fundamental role that it can be called the "most important" ingredient in the development of this forecasting system. The absence of any one of them would almost certainly limit the impact of this project. Any success that this project does achieve is due, in large measure, to the tremendous efforts that have gone on before in each of these fields.

An appropriate thought was expressed by Sir Isaac Newton hundreds of years ago:

"I can only see as well as I do because of the shoulders that I stand on."

Part III

Methodology

Introduction

As discussed in part I, the following questions will be addressed in this research:

1. How can currently available technologies not commonly utilized in pricing in the TL industry be harmoniously incorporated into a state-of-the-art pricing suggestion system?
2. What is the pricing system that this research will construct and suggest to advance the current state-of-the-art?
3. Can the DPDST described be operationalized?
4. Would an accurate, detailed pricing suggestion system actually benefit a firm?
5. What are the various uses that a firm can find for such a system?
6. What are the desirable consequences of implementing this system?
7. What are the undesirable consequences of implementing this system?
8. How would customers be influenced by this system?
9. What would the economic cost of this system be to a firm?
10. What is the economic value of this system to a firm?

Part II gave a partial answer to the first question as it considered available technologies and how they will be utilized in the development of the DPDST being proposed. The current part of this dissertation will discuss how the answers to the above listed questions will be completed. The findings will then be detailed in part IV as the DPDST is actually developed, operationalized, tested, and evaluated.

The information in this part is divided into six sections: "Introduction", "System Development", "Data Preparation", "Prototype Development", "Value of the DPDST", and "Summary". The first section gives a brief overview of the infor-

mation covered. "System Development" addresses how question two will be answered by describing the theoretical development of the DPDST. The third and fourth sections, entitled "Data Preparation" and "Prototype Development", will deal with question three. These sections will discuss preliminary research and investigations that have been accomplished, as well as plans for additional steps needed to develop and operationalize the prototype. In particular, "Data Preparation" will describe the necessary data manipulations and statistical analyses that must be performed prior to implementing the system in an operational prototype and "Prototype Development" will describe the steps that will be taken to develop a fully functional software prototype of the pricing suggestion system, in preparation for its placement on-site with industry partner(s). The fifth section, "Value of the DPDST" will deal with research questions four through ten and will outline how the value of the pricing suggestion system will be determined, both objectively and subjectively, with the assistance of industry partner(s). The sixth section will summarize the information presented.

System Development

The development of the DPDST will consist of a written description that will satisfy all the claims made in the previous two parts. There will be no consideration for the implementation of the DPDST during this descriptive stage. (This will be delayed until the prototype is developed.) The dynamic price suggestion system description will consist of diagrams, explanations, and discussions that will define the DPDST. This part of the research would best be classified as Process Research, which is defined as "[a] subdivision of applied research, whose objective is a new or improved process"¹ where applied research is defined as follows:

"Applied research has as its object the attainment of a practical goal such as a new process or piece of equipment. An example is the provision of design data for a nuclear powered submarine or the determination of the cause of the specific failure of a particular crop and the derivation of a remedy to prevent its recurrence."²

In this development stage, the system will be presented step by step, in the same order that the data will be processed. That is, the descriptions will follow the flow of data manipulations beginning with data collection and concluding with the suggestion of a price. The automatically correcting feedback loops and the necessary and allowed user interactions alluded to earlier will be described

1. Lord Rothschild, pp. 373-378.

2. Lord Rothschild, pp. 373-378.

naturally as they occur in the flow of data manipulations. Also, the system will be presented from other viewpoints that emphasize its unique, multidimensional characteristics and its many features. Discussions of the features of the system will be woven naturally into all phases of the presentation. Many of these features already have been introduced and will be referenced and briefly reviewed as they are placed in their proper position in the system development.

Table 4 lists some of the more important attributes and features that will be incorporated into the DPDST. It should be noted that since the system specifications necessary for the creation of the software prototype will be included in the system development and descriptions, these descriptions will provide a blueprint for the creation of the software prototype. The plans for the development of this software prototype will be discussed later in the section entitled "Prototype Development".

TABLE 4

DPDST Attributes

Attribute		Description
1.	Uses on-line data	Links will be formed between the DPDST and the existing information systems. These links will provide data to the DPDST as it is collected, allowing the DPDST's suggestions to incorporate the most recent historical data.
2.	User definable and easily redefined	Will allow the user to customize the system to reflect his/her immediate attitudes and/or concerns. For example, there may be occasions when the user may be interested in measuring total costs and other times when all costs excepting taxes and capital costs would be wanted. The system will allow the user to dynamically switch from one analysis to another.
3.	Incorporates EVA, if desired	Will include the ability to include or not include, as well as to customize the use of EVA in cost measurements. Customization will include the ability to define the cost of capital on individual or aggregated capital costs.
4.	Incorporates ABC, if desired	Will include the ability to measure costs using ABC philosophies. Specific cost measurement definitions will be user definable, again making the prototype extremely adaptable to any given firm's requirements or management wishes.
5.	Many state of the art technologies included	In addition to ABC and EVA, will use such technologies as advanced database manipulation and design, probabilistic neural network (ITS) analyses to statistically define geographic market segments, etc.
6.	Automatically interprets data	Will automatically interpret and optimally disaggregate the data being considered. Interpretations of historical data will be presented understandably without user involvement. The user will only need to inform the DPDST of a few minimal facts such as origin and destination.
7.	Optimizes degree of data disaggregation	Will use probabilistic neural networks (ITS) to optimally determine geographic market segments. This allows geographic market segments to be defined as soon as there is enough collected historical data with a small enough variability to adequately forecast future business with a reasonable degree of confidence.
8.	Interactive	Will allow the user to interact with the data through the DPDST in real time to increase the user's intuition and understanding of the market segments being studied.

TABLE 4

Continued

	Attribute	Description
9.	Ability to include unusual costs such as taxes, driver retention, etc.	Will include the ability to measure costs that are not typical in TL information system's costing function. Some examples of these costs are taxes, capital costs, driver retention/retraining, number of trailers used, etc.
10.	Includes detailed fuel and fuel tax costs	Will include the ability to measure fuel costs using state by state prices, state by state fuel taxes, and seasonal fuel efficiencies. As discussed in part I, this ability is important (see discussion on page 25) due to the sensitivity of profits to these variations.
11.	Includes assessorial charges	Will include the ability measure the cost of assessorial stops. This ability is important since the number of assessorial stops per shipment varies widely. The sensitivity of profits to this measurement is even more significant than the previous item discussed (fuel).
12.	Includes driver retention/retraining costs	Will include the ability to measure this cost on a geographic market segment basis. This is important since anecdotal evidence exists that suggests that drivers have a greater likelihood of quitting when serving some market segments than others.
13.	Inclusion of non-revenue activity	Will include non-revenue activity such as non-revenue generating miles and non-revenue generating time. This will allow non-revenue generating activities to influence cost measurements on a geographic market segment basis.
14.	Facilitates the use of multiple cost measurement definitions for sensitivity analyses	Will include the ability to switch among multiple cost measurement definition files, where each file can contain different cost measurements or estimates. Switching the cost definition file will allow costs to be recalculated using the newly chosen cost definitions. In this way, sensitivity to cost definitions or to cost drivers can be determined.
15.	Facilitates comparisons of suggested prices to historical prices	As illustrated below (see Proposed Results Screen for DPDST Prototype, figure 17, page 109), historical prices and suggested prices will be shown prominently on the screen. Additionally, histograms showing the variation in the historical prices and time series graphs showing trends in historical prices will be available to give an understanding of historical pricing.

TABLE 4

Continued

Attribute		Description
16.	Sensitivity, trend and variation analyses	Will include the ability to interactively and immediately run sensitivity analyses of historical prices, demand, cost definitions, cost drivers, etc., as well as trends and variability of key measurements such as historical prices, non-revenue generating mileages, etc.
17.	Independent of historical database tables	Will include the ability to use <i>any</i> set of database tables that are appropriately configured. The prototype will access these external database tables and use their contents in its analyses. By changing the database tables, the prototype can be used by anyone able to configure their transaction databases appropriately, making the prototype potentially adaptable for use by any TL firm.
18.	Feedback loops	Will continuously improve and control decision-making, updating the degree of data disaggregation and forecast results by combining information from previous decisions with current data to influence future decisions.
19.	Forecasts	Will interactively use exhaustive on-line data to forecast business activities such as non-revenue generating miles, and non-revenue generating time.
20.	Suggests instead of sets prices	As previously mentioned, the DPDST is a suggestion system rather than a decision-making system. It is intended to enhance management's decision-making abilities rather than replace it.
21.	"Correction" of input data	Will identify data that differs significantly from management's expectations. When appropriate, it will discard or replace the data with appropriate entries.
22.	Includes all dimensions of price	All dimensions of price discussed in part II, such as cost, demand, customers, competition, etc. will be included in the DPDST.
23.	Easy to use	Will require little training so that it can be used by all levels of management as well as front-line personnel.

Data Preparation

Once the proposed pricing system has been theoretically developed and described, its actual implementation, development, and testing will require both large amounts of data and significant data manipulations. For example, the use of on-line transaction data as proposed in this system requires access to exhaustive historical data. This data must cover a time frame large enough to give a fair representation of current business trends as well as accurate short term forecasts. Because of the amount of computer time required for the development of the proposed system, data from industry partner(s) will need to be transferred from their MIS computers to R&D and test machines that will be dedicated to the implementation of this system.

In conjunction with the transfer of data to R&D and test computers, the format of the data will need to be extensively manipulated to be useful for this research. There are several reasons for these data manipulations. First, the data currently collected by TL firms is typically spread over many related "database tables". The data from these multiple tables must be joined properly for the research to proceed efficiently. Preliminary investigations suggest that the raw database tables occupy in excess of several hundred megabytes of accumulated disk space storage. The original structure of these tables does not lend itself to on-line, dynamic analyses such as those proposed for this pricing system, and will need to be adapted to make the data more usable.

Another reason that extensive data manipulation will be required is that the data is often entered by hand and data collection definitions or data entry errors make some of the data inappropriate for this research in its raw form. For example, this research will forecast revenue generating time for given geographic market segments based upon historical data. It is not uncommon for a truck to pickup a shipment on Friday with delivery demands for Tuesday or Wednesday. This often allows the driver to spend the weekend with his/her family, performing the driving on Monday and Tuesday. In this scenario, to measure revenue generating time as five days (Friday to Wednesday) is inappropriate. Three days is a more accurate representation of what happened than the five days described in the historical database. Also, obvious data entry errors should be corrected or discarded. For example, when a shipment takes a year and one day for delivery, it is likely a data entry problem. This is especially true when these errors occur around the first of the year. The collected data should be "cleaned-up" to remove such inappropriate measurements.

Another important step that will be required to adequately utilize the data is indexing (sorting) in various ways for quick retrieval. The ability to retrieve desired data quickly will allow forecasts to be restricted to any given geographic market segment in real time. Without this, no real-time forecast or price suggestions would be possible.

The process involved in all of these data manipulations is flowcharted in figure 14. There are five stages in the flowchart. These are as follows. 1) data collection by the industry partner(s). 2) Transfer of the data from the original database tables to R&D and test machines. 3) Combining of the data from the many

Data Preparation

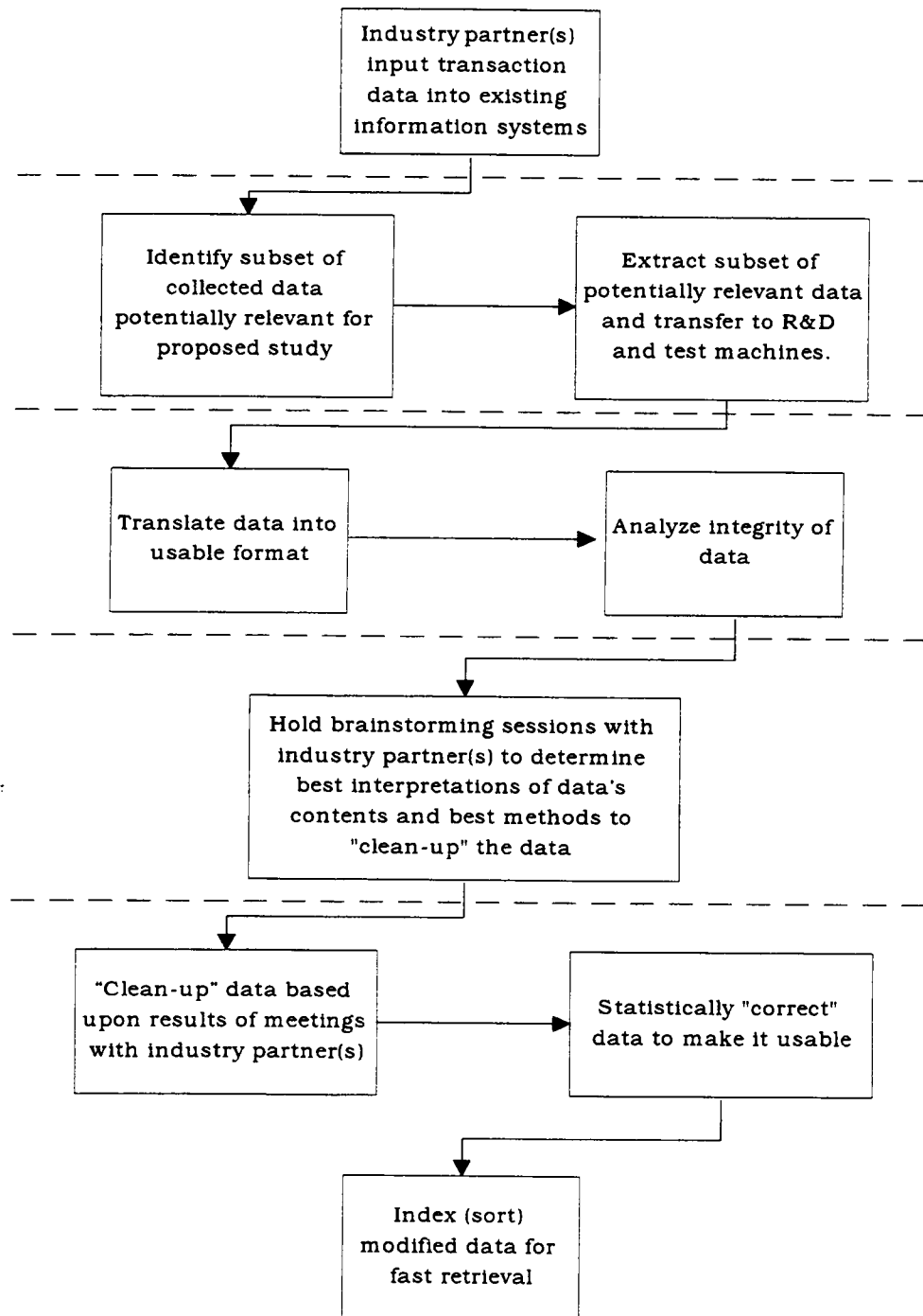


FIGURE 14 Steps in Data Preparation

related tables into a usable format and inspection of the resulting data table(s) for usability and integrity. 4) Brain-storming with industry partner(s) about best ways to use and interpret the data. And lastly, 5) Clean-up of the data and final preparations for the data utilization in this research. Each of these stages are significant and will be treated in the discussion that follows.

The first stage needs very little discussion as it was done by industry partner(s) before the research was even contemplated. The proposed research does not, in any way, attempt to influence this stage.

The second stage, the transfer of data from the original database tables to R&D and test machines involves a great deal of thought and work. Initial tests and investigations suggest that the tables must be exported from the user's common file format into a more universal file format such as EBCDIC or ASCII. The data then must be adapted and imported into a useful file format so that they can be manipulated, inspected, indexed and so on.

The fourth stage allows industry partner(s) to influence the interpretation of the data. This is an extremely important step, and will involve a considerable amount of discussion and survey with mid- and upper-level management from several industry partners in order to assure that the data accurately represents "real world" experiences in the TL industry. Any questions concerning how the measurements might occur or which records should be considered suspect must and will be discussed with management during this stage. This stage also yields in-depth descriptions of measurements that might be expected, as management will be able to explain, for instance, expected delays in certain routes (such as increased time going through a major metropolitan area) or expected time variations from season to season on a particular route.

Stage four allows management to give detailed mathematical descriptions of expected linear relationships among the measurements. For example, revenue generating time can be explained as a linear function of linehaul mileage, whether or not the shipment passed through a large metropolitan areas during rush hour, the number of assessorial stops, etc. Since the management of the industry partner(s) that we anticipate working with are able to predict on-time delivery more than 98% of the time, the linear relationships that they use or suggest should correlate closely with the recorded measurements. By obtaining this description of expected measurements, data that appears grossly miscalculated can be identified easily. Further discussion will then facilitate any necessary corrections or modification to the data. These will be used in stage five to "clean-up" the data. Stage four is important so that the experience of industry partner(s) can be combined with the theoretical background already discussed.

The fifth stage puts the data into final form. The first step in this process is to remove or correct all obvious errors. For example, in preliminary experiences, sample data which was meaningless or misleading was found in an industry partner's historical databases. This data was created to aid MIS personnel in setting-up the system. It continued to be used for such purposes intermittently. These sample records do not belong in the final database tables created for this research. Similarly, other records need to be removed for a variety of reasons such as clerical errors. The removal of these records allows the remaining data to be cleaned-up and used in the proposed DPDST.

After the necessary data is discarded, the remaining data needs to be "cleaned." This includes arithmetically manipulating some of the data to obtain compound measurements such as revenue generating time which is obtained by measuring the time from pick-up to delivery. For example, the compound mea-

surement of revenue generating time is derived from four historical fields, namely date and time of pick-up and date and time of delivery. Once these compound measurements are created, the records which agree within 20% with management's expectations will be considered to be correct. A regression analysis using an ITS scoring criteria will be used to determine the linear equation most appropriate to identify this correct data mathematically. For example, management may believe that the average driving speed of their vehicles is 58 m.p.h. The regression analysis may show that the driving time is better explained with a driving speed of 61 m.p.h. The results of the regression analysis also may show that some variables are not important to explain driving time. As discussed in part II, a parsimonious model will be pursued. ITS will automatically identify the optimal variable set and the optimal linear coefficients to use in the linear regression. The resulting linear regression equation should fine-tune and enhance management's beliefs in spite of their 98% on time delivery rate. This is important since the difficulty of correctly understanding the data in the form provided by industry partner(s) is compounded by its tremendous volume. (This situation was emphasized during preliminary conversations with industry partners when different managers could not agree on some fine points of data interpretation.³)

Because of the differing opinions of management as to the correct interpretation of the data and because of the inherent problems in the recorded data, the resulting linear regression will be used, when needed, to "back populate" (replace) the actual data. For example, the revenue generating time field will be

3. For instance, one manager felt that each assessorial stop usually takes 1 hour while another felt that the time was closer to 2.5 hours. This significant difference emphasizes why management should try to augment their own experiences with decision-support tools.

populated by the regression equation whenever the recorded data differs from the result of the regression equation by more than 20%. This mechanism effectively removes most problems from the data such as the influences of maintenance, long, non-productive weekends, etc. The resultant data should represent fairly the actual operating environment of the business partner providing the data that should be used to suggest prices. When this step is completed, the database tables should be ready to be indexed (sorted) and used in the proposed DPDST.

This portion of the research would best be classified as a hybrid between product and process research. Lord Rothschild would categorize the development of the underlying methodology as process research. The building of a pricing tool such as the one suggested would best be classified as product research.⁴

4. Lord Rothschild, pp. 373-378, where product research is defined as: "[a] subdivision of applied research whose objective is a new or improved product." and process research as: "[a] subdivision of applied research whose objective is a new or improved process."

Prototype Development

Once the data has been collected, manipulated into a usable format, and “cleaned-up” with the help of management, a software prototype of the pricing system will be developed.⁵ One of the main motivations for the development of the prototype is to demonstrate that the DPDST can indeed be made operational. Another important incentive is to test the utility of the DPDST in a “real-world” setting.

Development Platform

In attempting to make the DPDST useful in a real-world setting, it was felt that the programming language and user interface were significant considerations. After substantial preliminary research of many different programming tools, Microsoft Visual BASIC for Windows has been chosen as the programming medium. The decision to use the Microsoft Windows™ platform followed significant investigation as well as discussion with industry experts. Relative advantages and disadvantages of various systems and environments, including the AS/400, CMS®, Macintosh®, MS-DOS®, Microsoft Windows®, UNIX®, and VAX were considered. Following the decision to use the Microsoft Windows platform, many programming languages and systems were reviewed and tested. In this pursuit, investigations of programming speed constraints suggested that it

5. This will involve many different aspects of product research. See page 103.

would be very difficult in the IBM compatible PC environment, if not impossible, to program a fair representation of the DPDST previously described using available dedicated database management systems (with the possible exception of Microsoft ACCESS, which required too much system RAM to make it a preferable option), so other options were explored.

The final choice to use Microsoft Visual BASIC[®] for Windows[®] was based upon the ease of programming that VISUAL BASIC[®] for Windows[®] offers, its mathematical speed,⁶ and the richness of the language. These qualities of the VISUAL BASIC language and its available tools should allow the incorporation of most, if not all, of the characteristics and planned features of the DPDST. Another contributing consideration in choosing Microsoft Visual BASIC[®] and its underlying Windows[®] platform was the ability to easily transport the prototype to industry partner(s)' machines, due to the ubiquity of machines able to run Microsoft Windows[®] (and thus a prototype created with Visual BASIC[®]). This should facilitate the placement and evaluation of the prototype on-site with industry partner(s). Furthermore, the use of the Microsoft Windows[®] should

6. Numerous benchmarks comparing the relative looping and arithmetic speeds of Borland C++[®], Microsoft Visual BASIC[®], TrueBasic for DOS[®], Microsoft Visual BASIC for DOS[®], Microsoft Access[®], GFA BASIC for Windows[®], Alpha Four[®], Alpha Five[®], dBase III+[®], dBase IV[®], Paradox for Windows[®], SuperBase for Windows[®], Borland PASCAL for DOS[®], Borland PASCAL for Windows[®], and MATLAB for DOS[®] showed that Microsoft Visual BASIC[®] was significantly faster than most programs in this critical area. When comparing the database speed functions, phone calls to manufacturers and personal comparisons demonstrated that Visual BASIC[®] using the embedded ACCESS[®] database engine rivals the speed of the dedicated database management programs, while providing ease of programming unavailable in C++ or similar programs, and thus significantly reduced system development time. For example, in one test of database speed, Visual BASIC[®] took 16 seconds to complete a speed test while dBASE III+[®], dBASE IV[®], Paradox[®], SuperBase[®], and Alpha Five[®] took over 7 minutes. In fact dBASE III+[®] took days to complete the test (test result had to be extrapolated due to the unexpected speed constraints). In fairness, it should be noted that C++ completed the same test in under 4 seconds. However, It will be noticed that Visual BASIC[®] is much closer in arithmetic and looping speed to the speed of C++ than the standard database management systems and, as mentioned, significantly reduces system development time compared to C++.

facilitate the industry partner(s)' ability to successfully use the prototype, as the Windows® environment is conducive to the creation of user friendly programs.

As mentioned, an important aspect of prototype development will be the incorporation of all of the characteristics of the DPDST discussed in the previous two parts and briefly outlined in table 4, page 94. In addition to these characteristics, several features of the prototype itself will be important in making this experiment as successful as possible. Table 5 below includes some of these key programming features that the prototype will include:

TABLE 5

Key Features of Software Prototype

	Key Feature	Description
1.	Windows® Platform	Will run on Microsoft Windows® 3.x
2.	Standard Windows® user friendly interface	Will follow standard Windows® conventions, including the use of standard menu structures, GUI interface, dll (dynamic link libraries) calls to standard Windows® I/O procedures, etc.
3.	Includes on-line help	Will include standard Windows® on-line help files.
4.	Allows copying and pasting of results to other programs for simplified proposal generation	Like many Windows® programs, the ability to copy from the DPDST prototype into other Windows® programs such as wordprocessors or spreadsheets via the Windows® clipboard will be included. This ability will facilitate the creation of customized reports or proposals.
5.	Includes histograms of key historical activities	Will include the ability to produce histograms of key historical activities such as historical prices, non-revenue generating mileages, and non-revenue generating time to aid management in sensitivity analyses.
6.	Includes time series graphs	Will include the ability to produce graphs of key historical activities in order to show trends and aid management in sensitivity analyses. For example, the ability to produce time series graphs of historical prices, non-revenue generating mileages, and non-revenue generating time will be included.

Design Input from Currently Available Costing Systems

In developing the DPDST operational software prototype, ideas will be borrowed from current costing systems. However, obvious and significant differences will exist between the DPDST prototype and these costing systems due to distinct objectives (pricing versus costing). For instance, one of the distinguishing features between the DPDST prototype and traditional costing models is the inclusion of historical prices. Thus, a notable distinction between the software prototype and costing models will be the inclusion, prominently on the screen, of measured costs and historical prices as well as suggested prices to aid in price determination.

The costing model that will influence the design of the computer screens, printed reports and cost measurement techniques most heavily will be an automated "STI" costing model that was presented at CLM in October 1994⁷ and which accompanies classroom packet materials used in carrier management courses at The University of Tennessee, Knoxville. This software will serve as a springboard for the prototype development as it incorporates many of the features discussed previously regarding ABC costing techniques and has been recognized as a state of the art, easy to learn, automated costing model for the motor carrier industry.⁸ Figure 15 shows how the screen appears in the STI model and gives a prologue of how the proposed DPDST prototype might appear upon completion.

7. See: Patton, 1994, p.149. See also: Gibson, et. al., p.10ff.

8. Gibson, et. al., p.10ff. See also: Mundy, et. al., Aug. 1994, pp. 3-5.

UNTITLED			
File Edit Calculate Help			
Worksheet Title			
[SAMPLE TRUCKLOAD PROBLEM]			
PU INFORMATION			
time out:	07:00	time returned:	11:00
Distance (Miles):	30	spent at all stops:	100
Time (minutes): spent at shipper:	100	Average Weight (lbs):	25000
No. of shipments handled at stop:	1	(Trailer)	455.75
Power Unit:	00073		
No. cartons:	200	Carton Wt. (lbs):	125
Carton size (cu.ft.):	12		
LINE HAUL INFORMATION			
Terminal:	Origin: 000	Destination:	100
Distance (Miles):	1246	Tractor:	00000
Trailer #1:	455.75	Wt. (lbs):	25000
Trailer #2:		Wt. (lbs):	
DELIVERY INFORMATION			
time out:	19:15	time returned:	23:30
Distance (Miles):	50	spent at all stops:	150
Time (minutes): spent at delivery:	150	Average Weight (lbs):	25000
No. of shipments handled at Stop:	1	(Trailer)	455.75
Power Unit:	00000		

FIGURE 15 Input Screen From STI Motor Carrier Costing System
Source: E. P. Patton, *Transportation Cost and Profit Analysis*, Graphic Creations, Knoxville, TN, Spring 1994, p. 149

It is worth mentioning that since the STI model is designed to measure costs for an LTL firm, while the DPDST is designed for use in the TLMC industry, some immediate simplifications should be possible. Ideally, the user will have to input only the origin and destination, the number of assessorial stops, and the number of trailers used. The proposed prototype will be designed to incorporate these simplifications. Figure 16 and figure 17 give an idea of the design of the screens that the prototype will incorporate.

Origin:

Destination:

Number of Assessorial Stops:

Number of Trailers:

FIGURE 16 Proposed Input Screen for DPDST Prototype

COSTS			
	TOTAL	REVENUE GENERATING	NON- REVENUE GENERATING
VARIABLE			
FUEL	510.88	390.56	120.32
LABOR	601.35	459.73	141.63
FIXED			
Salaries	15.03	11.49	3.54

Historical Prices

Low Price:

Average Price:

Suggested Price:

High Price:

FIGURE 17 Proposed Results Screen for DPDST Prototype

The above example screens are only preliminary ideas of how the prototype will appear. Multiple improvements and additions, in consultation with industry partner(s), are anticipated in order to increase the usability of the system.

The development of this prototype would best be classified as product research by Lord Rothchild's already cited article. This is akin to the celebrated Nobel prize winning ink spot experiment. The theory already existed but the operationalization of the theory required the development of innovative ideas that took the time and efforts of many persons.

Value of the DPDST

As previously mentioned (see page 9), preliminary investigation has indicated that the proposed DPDST will greatly advance the state of the art in pricing, particularly in the TL industry. This will be discussed in some detail under the heading "*Contributions of the DPDST*". Careful planning will be required in order to measure the impact of these contributions. Measurements will be accomplished both through the use of written and oral surveys and through analyses of the effects, or possible effects, of the DPDST on the profitability of industrial partner(s). These measurements of the impact of the contributions (in other words, the value) of the DPDST will be divided into two categories, namely, 1) perceived value and 2) economic value.

It is anticipated that the DPDST will deliver many benefits that cannot easily be measured economically. For example, some negotiation preparation functions might be "pushed down" to lower level management or even to front-line personnel. This might have the effect of freeing upper level management's time for more productive and creative activities. Another benefit might be that the DPDST simply increases confidence in setting prices. Also, the tool might be used to reduce variation in pricing practices such as differing pricing habits among different sales persons. Such perceived benefits will be discussed in the sub-section entitled "Perceived Value".

Economic value will be assessed by measuring the influence that the DPDST (actually, the operationalized prototype of the DPDST) brings to industry

partner(s)' profitability and economic activities. This will be suggestive of the value that it might add to TL firms in general. (The findings will be generalizable to the degree that the industry partner(s) represent the TL industry.) Measurements of the economic value created by the DPDST prototype will give an opportunity to measure the potential impact that such a tool might play as firms seek to gain a competitive advantage.

Contributions of the DPDST

It should be noted that while several commercially available systems designed for use by TL firms include rudimentary cost analysis as part of their package, the costing these systems perform is inadequate at best, and pricing is seldom, if ever, directly addressed.⁹ The commercially available alternatives to the proposed system have a different emphasis and are intended for different purposes than the specialized DPDST developed in this research.¹⁰ Therefore, it is not surprising that these other systems do not include the variety of details found in the system herein proposed. The contribution that such a system brings to the literature and to the TL industry can be seen by comparing some of the key features included in this DPDST with some of the popular state-of-the-art programs currently available. By way of example, the Table 6 shows some of the key features that distinguish the proposed DPDST system from one of the commercially available, state-of-the-art alternatives, *Traffic Analyzer*, marketed by Innovative Computing Corporation as a module of their Innovative Transportation System for the AS/400.

9. See discussion on page 9, and in footnote 21 on p. 10.

10. See for example: "User's Guide," AS/400 Traffic Analyzer, Innovative Computing Corporation, Oklahoma City, Oklahoma, 1994, pp. 1-3.

TABLE 6

Comparison of Prototype Versus Commercially Available Software

Key Feature	Proposed DPDST	Traffic Analyzer
Statistically cleans data	YES	NO
Optimally defines geographic market segments using ITS	YES	NO
Report Based	NO	YES
Microsoft Windows® Platform	YES	NO
Interactive	YES	NO
"Corrects" data for input errors or problems	YES	NO
Market segment definitions require minimal data volume	YES	NO
Includes EVA	YES	NO
Allows comparison of multiple cost definitions for sensitivity analyses	YES	NO
Includes graphs for sensitivity analyses	YES	NO
GUI interface	YES	NO
Requires extensive training	NO	YES
Can include many tax measurements (income, workman's comp., FICA, etc.)	YES	NO
Allows detailed descriptions of costs	YES	NO
Incorporates ABC techniques	YES	NO
Can include delineated costs of debt	YES	NO
Produces detailed costs reports	YES	NO
Calculates fuel costs on a state by state basis	YES	NO
Calculates fuel tax costs on a state by state basis	YES	NO
Accounts for varying driver retention/retraining costs from geographic market segment to geographic market segment	YES	NO
Designed as a pricing tool	YES	NO
Forces fixed costs to be measured on a per hour basis	NO	YES
Forces variables costs to be measured on a per mile basis	NO	YES
Gives details explaining costs measurements for future reference or cost sensitivity analyses	YES	NO
Includes Assessorial charges	YES	NO
Allows users to limit data when variability is high	YES	NO

That the proposed DPDST is so significantly different from commercially available alternatives in no way suggests that one system is better or more useful than the other. Instead, it gives an example of how this business activity, pricing, has received inadequate attention up to this point in the TL industry and of the significant contribution the DPDST, as proposed, should bring to both the literature and to industry.

Perceived Value

The perceived value of the DPDST will be measured with the aid of two survey instruments (see Appendices A and B to this part, page 124 and page 127) as well as through informal interviews and observations. The first survey will be administered before the DPDST is implemented, and the second after the evaluation period has been completed. This will allow measurements and comparisons of changes in perception due to the use of the DPDST. The surveys will directly address research questions four through eight, as follows:

4. Would an accurate, detailed pricing suggestion system actually benefit a firm?
5. What are the various uses that a firm can find for such a system?
6. What are the desirable consequences of implementing this system?
7. What are the undesirable consequences of implementing this system?
8. How would customers be influenced by this system?

Relevance of Survey Questions

Discussions regarding the survey are included in this sub-section on perceived value because the surveys are intended to answer the above research questions directly. Note that some of the survey questions will serve a dual purpose in that they will answer the research questions mentioned and will also contribute towards a more complete understanding of the economic value of the

DPDST. However, the contribution of the survey to an understanding of the economic value of the DPDST is a secondary benefit.

Research Question 4

4. Would an accurate, detailed pricing suggestion system actually benefit a firm?

This question actually addresses both perceived and economic value, so only a partial answer to this question will be obtained through this part of the survey. The economic aspect will be commented on in the sub-section titled "Economic Value". The research question is addressed by the first four questions of the survey.

The contents of the first four survey questions are as follows:

- On what percentage of market segments do you feel comfortable with your current knowledge of cost characteristics?
- Please record your best estimates of the total costs to serve each of the following 25 market segments and the starting and ending time to make these estimates.
- Please record which of the following 25 market segments you believe to be profitable.
- How useful do you anticipate (did you find) the DPDST to be?

The answers to these questions should reveal whether or not users of the prototype find the DPDST valuable.

Research Question 5

5. What are the various uses that a firm can find for such a system?

This research question will be answered by survey questions five through nine. These survey questions are as follows:

- What will be (were) the principal uses of the DPDST?
- How often will the DPDST be used (was the DPDST used) by: 1) upper-level management, 2) marketing personnel, or 3) front-line personnel?

- Will (Did) the DPDST affect the use of "brokering," and if so, how?
- What role, if any, do you expect (did the DPDST) to play in dedicated business negotiations?
- What role, if any, do you expect (did the DPDST) to play in the negotiation of total logistics system services?

The "post" survey looks at several different and anticipated uses of the DPDST that might occur throughout the experiment. It also asks open ended questions that will allow participants to report any unexpected uses of the DPDST such as: 1) use by marketing persons in negotiations off-site, 2) use by management to eliminate unprofitable business, 3) use by front-line personnel to negotiate spot market sales, or 4) use by operations to improve efficiency of equipment utilization.

Research Questions 6 and 7

6. What are the desirable consequences of implementing this system?
7. What are the undesirable consequences of implementing this system?

These research questions will be answered with survey questions ten through fifteen. The questions below describe the contents of the survey questions.

- What conflicts, if any, will occur (occurred) as a result of implementing the DPDST?
- What conflicts, if any, might be (were resolved) as a result of using the DPDST?
- Do you expect (Did) the DPDST [to] influence corporate policy (allocation of overhead, shared costs, etc.)? If so, how?
- Would a better understanding of costs, historical prices, etc., as supplied by the DPDST help drive down variability (variability in prices, profits, etc.)?
- What attributes or features of the DPDST might provide (provide) the greatest benefit?
- What attributes or features of the DPDST do you anticipate will introduce (introduced) the greatest concern or aggravation?

These six questions should provide a general understanding of the desirable and undesirable consequences of implementing a DPDST and contribute to the understanding of its perceived value. The surveys look at several ways that the system could be considered desirable or undesirable by its users. One of the questions is open ended and asks for detailed descriptions of the points that the participant feels are worth mentioning.

Research Question 8

8. How would customers be influenced by this system?

This research question will be answered with questions sixteen through twenty-one of the survey. The questions below describe the contents of the survey questions.

- How open do you expect to be in negotiations with the information provided by the DPDST?
- How will the information provided by the DPDST influence customer service levels?
- How do you believe that the information provided by the DPDST will influence (influenced) customers?
- Do company prices follow measured costs?
- How often do prices fall below totally allocated costs?
- How useful do you consider the DPDST?

The survey questions address the ways that customers might be influenced (or that users of the DPDST feel that customers might be influenced) by the implementation of the DPDST. These questions should give a reasonable understanding of how the DPDST will influence customers.

Economic Value

Because of the unique capabilities of the proposed DPDST, it is anticipated that it will bring some increased profitability to the industry partner(s) that utilize it and that it might influence decisions that affect the profitability of the company. In order to test these hypotheses, answers to the ninth and tenth research questions, as well as a completion to research question number four will be sought:

4. Would an accurate, detailed pricing suggestion system actually benefit a firm?
9. What would the economic cost of this system be to a firm?
10. What is the economic value of this system to a firm?

A complete answer to research question four will only come as research questions nine and ten are answered. However, a partial understanding of the economic benefit that the DPDST provides will be determined by any reorganization in the activity of the company that occurs in part or in full due to the DPDST. This will be studied both informally, by maintaining close contact with users of the DPDST prototype and with upper-level management of the industry partner(s), and formally through the use of the survey instrument already mentioned. In particular, survey questions six through fifteen should provide insight into the economic benefit of the DPDST. These survey questions address the expected use, then the actual use of the DPDST by the industrial partner(s), as well as investigating some possible areas of influence within the organization and operating patterns of the firm. Any reorganization will influence the reported economic value that the DPDST adds to industry partner(s).

Research question nine will look at several aspects of costs of implementation of the DPDST. These will be addressed both by discussion and survey, as well as actual cost measurement.

The tenth research question will address the question of economic value both through use of the survey instrument and by measurements and analyses of the effects that the DPDST has on the profitability of industry partner(s). The economic value that the system adds to a firm will be measured by comparing profitability levels before and during the experiment. It will also be measured subjectively by eliciting opinions from users on the survey. For example, the following question captures the content of the last two survey questions.

- How much do the participants value the DPDST (monetarily) and how does this change over the course of the experiment?

These last survey questions ask about the economic value that users place on the system and will give a measure of the system's economic impact. These subjective and objective measurements should yield an understanding of the economic value that a DPDST such as is proposed in this research might bring to a firm.

As mentioned, the economic value will be measured, in part, by comparing levels of profitability from before and throughout the experiment. One method that will be used to obtain these measurements will be to measure 50 randomly chosen transactions that occurred before beginning the experiment of placing the DPDST on-site and 50 transactions that had the opportunity to use the aid of the DPDST in the establishment of a price. The profitability of the transactions will be measured and compared. The comparisons will include overall profitability, variation among the profitability of the transactions within groups, variation

among the profitability of the transactions between groups, and the likelihood of a transaction from a particular group to be profitable.

A further analysis will be done with 50 randomly selected transactions. These will be analyzed using the DPDST which will identify any unprofitable transactions. Calculations will then be made to find out how much over-all profitability would be influenced if the transactions designated as unprofitable by the DPDST's criteria were eliminated or made to "break-even." Finally, the influence of "brokering" the unprofitable transactions to owner-operators will be evaluated.

In addition to the direct questions and methods just discussed to answer the economic value research questions, survey questions two and three should contribute to a more complete understanding of the economic value that the DPDST will add to the industry partner(s). Recall that in survey questions two and three the industry partner(s) will be asked to evaluate prices of providing service to several market segments prior to introducing the DPDST on site. When reevaluating the prices, the question will be posed as to whether or not they would attempt to change the price based upon the information provided by the DPDST. This actually measures confidence in the prototype and could be classified as a measurement of perceived value. However, this does measure added economic value to the extent that management's opinions on the prices reflect reality. Since upper level management will be participating in these exercises, it is hoped that this will be valid. Additionally, if, through use of the DPDST, management determines that a particular offer should not have been extended, then this information is quite strong and can, with some degree of confidence, be used to measure the economic value of the system.

The accumulation of these various measurements of the economic value that the DPDST adds to the industry partner(s) should grant some degree of confidence in our comprehension of the influences to profitability that such a tool might add as it is implemented in the TL industry.

Summary

In this part of the research, the methodology that will be used to answer the research questions proposed in part I has been discussed. As mentioned, some of the points posed by these questions were answered indirectly in part II, through discussions of contributions from existing literature and of newly developed technologies. However, the majority of the research questions will be answered directly. For example, the ability to operationalize the DPDST will be shown by creating an operational software prototype. The conclusion to the answers to the research questions will be reported in part IV.

In answering the research questions, a pricing suggestion system (a DPDST) will be developed. Its creation will serve the purpose of explaining how the various competing dimensions of price can be brought together into a harmonious system. The DPDST will be shown to be operational through the creation of a software prototype that will be placed on-site with industry partner(s). The implementation of the software prototype will require significant manipulations of existing data in order to be functional. Once these manipulations are accomplished and the prototype is placed for an evaluation period with industry partner(s), measurements will be made of the perceived and economic value that the DPDST adds.

A two part survey instrument, with one part administered before the experiment begins and one administered after the experiment ends, will give answers to many of the research questions. Finally, the potential change in profitability

that the DPDST brings to industry partner(s) will be evaluated by measuring the effect of the prototype on profitability.

In short, the research will: 1) develop a DPDST, 2) program a software prototype of the DPDST, 3) prepare the data, 4) administer a survey instrument to industry partner(s), 5) place the software prototype on-site with industry partner(s), 6) interview users' of the prototype and upper-level management throughout the experiment, 7) administer a survey instrument with industry partner(s) after the experiment period is over, 8) through the use of evaluations previously described, measure both the perceived and economic value of the DPDST by measuring the impact of the prototype on attitudes, activities, and profitability, and 9) analyze the results of the surveys and informal interviews. These steps should yield answers to the research questions proposed in part I.

Appendix A

Preliminary Survey

1. What is your best estimate of the TOTAL costs to serve the following market segments? Please record the time it takes to calculate these estimates.

time start: _____

ORIGIN	DESTINATION	COST
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		
9)		
10)		
11)		
12)		
13)		
14)		
15)		
16)		
17)		
18)		
19)		
20)		

ORIGIN	DESTINATION	COST
21)		
22)		
23)		
24)		
25)		

time end: _____

How did you arrive at the above estimates? _____

2. Please identify which of the following market segments you believe to be profitable.

ORIGIN	DESTINATION	✓ if profitable (blank otherwise)
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		
9)		
10)		
11)		
12)		
13)		
14)		
15)		
16)		
17)		
18)		
19)		
20)		

ORIGIN	DESTINATION	✓ if profitable (blank otherwise)
21)		
22)		
23)		
24)		
25)		

End of preliminary survey

Appendix B

Final Survey

1. On what percentage of market segments do you feel comfortable with your current knowledge of cost characteristics?
-

2. What is your best estimate of the TOTAL costs to serve the following market segments? Please record the time it takes to calculate these estimates.

time start: _____

ORIGIN	DESTINATION	COST

ORIGIN	DESTINATION	✓ If profitable (blank otherwise)

4. How useful do you feel the pricing suggestion system (DPDST) is? (Please circle one response)

(Not Useful) 0 1 2 3 4 5 (Very Useful)

5. What do you believe to be the principal uses of the DPDST?

6. How often was the DPDST used by:

(Please enter a number in the blank and circle the appropriate time frame.)

upper-level management _____ daily weekly monthly seldom, if ever

marketing personnel _____ daily weekly monthly seldom, if ever

front-line personnel _____ daily weekly monthly seldom, if ever

7. Did the DPDST will affect the use of "brokering," and if so, how? If not, do you see a place for the DPDST in brokering after having used it?

8. What role, if any, did the DPDST to play in dedicated business negotiations?

9. What role, if any, did the DPDST to play in the negotiation of total logistics system services?

10. What conflicts arose in implementing the DPDST?

11. What conflicts did the DPDST help resolve?

12. Do you expect the DPDST to influence corporate policy (allocation of overhead, shared costs, etc.)? If so, how?

- 13.** Would a better understanding of costs, historical prices, etc., as supplied by the DPDST help drive down variability (variability in prices, profits, etc.?)

- 14.** What attributes or features of the DPDST provide the greatest benefit?

- 15.** What attributes or features of the DPDST create the greatest concern or aggravation?

- 16.** How open were you in negotiations with the information provided by the DPDST?

- 17.** How do you expect this system to help in establishing customer service levels?

- 18.** How do you think the DPDST does or might influence customers?

19. Do company prices follow measured costs?

___YES ___NO (check one)

20. How often do prices fall below totally allocated costs?

(Never) 0 1 2 3 4 5 (Always)

21. Would you recommend continuously investing in this technology (the DPDST or something similar) to improve its reliability, increase its feature set, etc. or is there a point of diminishing returns? (Please explain.)

22. If you were to recommend company-wide implementation of the DPDST, how much would you recommend the company spend for this implementation?

End of final survey

Part IV

Research Results

Introduction

The process of creating the dynamic pricing suggestion system covered a period of several years, and involved feedback both from pricing experts and from industry partners. In the end, all of the research questions posed in part I were answered.

The DPDST, once completed, incorporated all the elements of pricing discussed in parts I and II. A software prototype was then developed in stages, as will be discussed in the second section, "Prototype Development". The prototype incorporated nearly all aspects of the DPDST. This will be illustrated in some detail in the discussion of prototype development.

The steps discussed in part III (see for example, figure 14, page 99) were followed in detail, both in the development of the theoretical system as well as the development and testing of the prototype. The steps leading to the completion of the DPDST and the accompanying software prototype were not always as efficient as the presentation suggests. However, the pattern that the development followed will be clear as the system and its prototype are explained.

Once the prototype was completed, the system was validated through examination of the on-site use of the prototype by industry partners. As proposed in part III, this was accomplished both through observation, discussions, and through written interviews or surveys of the personnel, both mid-range and upper-level management, who utilized the prototype. The written interview stage of the validation proved so time consuming for the industry partners that only

three individuals participated (a vice president of operations, a pricing analyst, and a costing and software analyst). In fact, the entire validation process proved time-consuming for the industry partners involved. The extensive efforts put forth by the many people involved was greatly appreciated by the author. Because of the time commitment involved, the scope of the validation had to be limited in some aspects.

In spite of the limitations brought on by the industry partners' time constraints, results of the evaluation of the economic and perceived value of the DPDST showed that it has the potential to play an important role in pricing in the TLMC industry. Written interview responses, as well as in-depth interviews revealed that the prototype was evaluated positively by the personnel exposed to it.

To further explore the possible economic impact of the DPDST, the prototype also was utilized to perform system profitability analyses, and the findings were discussed with upper-level management. These managers expressed general consensus that the findings were accurate. Management further expressed the opinion that such information, made readily available to them via the DPDST prototype, could enhance their management abilities.

The development and validation of the DPDST and its prototype is outlined in the following sections.

Development and Presentation of System (DPDST)

In this section, the DPDST will be presented in a sequential manner, stage by stage. In each stage, a dimension or dimensions of pricing will be added to the system. The first stage involves only the dimension of cost. After this is developed, the pricing system will then be expanded through the addition of the other dimensions of pricing previously mentioned. When fully operational, the DPDST will not only be useful in suggesting a price for a proposed shipment, but will also offer the ability to identify existing pricing practices that need attention. When all dimensions of price as well as the necessary tools for improving pricing practices are incorporated and harmonized, the system will be complete, a fully developed Dynamic Pricing Decision-Support Tool.

Stage One—Costing Dimension

Objective of Measuring Costs

One of the critical concerns in establishing a price is that costs must be covered. The objective of cost measurement in this study must be kept in the forefront at all times. This is true for all pricing decisions, even when prices are set below totally allocated costs. For example, although management might decide initially only to cover variable costs in a penetration strategy or to adapt prices to some other strategy, cost information should always influence pricing

decisions. However, management might choose to balance cost information with other concerns.

In fact, as discussed in part II¹, cost should not be the only dimension considered in the successful establishment of a price. However, accurate costing establishes the lower bound, or floor, and a basis for any price. The first step, therefore, in the construction of the DPDST, is the construction of a flexible costing module. One should remember that determining costs is only a small first step in the establishment of a suggested price. The DPDST's ability to appropriately suggest a price will be enhanced in the following sub-sections as other modules are added.

In measuring the cost that a proposed shipment will incur, there is seldom a number that represents the "correct" or "precise" cost, with whatever internal meanings these terms might connote to the reader. This is true because, while it is natural to consider a given shipment to be an atomic unit that can and should be costed "correctly", there are always operational, customer, and situation specific variables that must be factored into the equation in order to get an appropriate picture of the costs for a particular shipment, regardless of what the shipment "usually" costs the company. For instance, a decision to use team drivers instead of a single driver for a given shipment or to drop a trailer off at place of origin for an extended time will greatly influence the cost of a given shipment. Thus, each shipment must be considered as a series of operational decisions that will influence the cost rather than as an atomic transaction based upon historical experience. Because of this, the DPDST calculates costs in such a way

1. See discussion on page 47, ff.

that the measured or estimated cost for a proposed shipment will lead to an appropriate suggested price for that particular shipment, as will be discussed.

Use of Historical Transaction Data

The most useful and precise way to estimate the cost of a proposed shipment is through the use of a company's historical data. Companies of moderate and large size, and even some smaller companies, have established routes and customer relationships that form a core framework upon which the rest of the business is built. Transaction data contains a wealth of embedded, though sometimes hidden information. Commonly collected transaction data is adequate to reveal cost driver levels, variances, and trends. This historical data identifies geographic market segments and records cost driver levels such as linehaul distance, linehaul time, non-revenue distance, non-revenue time, customer, day of week, etc.

Since transaction data often is not organized optimally for pricing, it can and should be segmented by several criteria. For example, the data can be segmented according to day of week, time of day, or customer. The DPDST will therefore segment historical data in a variety of ways. This allows management to consider if prices need to differ according to the criteria by which the data is segmented. For example, does a particular customer warrant a different price than everyone else on a particular geographic market segment, or does a lane imbalance change from day to day or from time of day to time of day?

Some of the historical data requires significant manipulations to expose the segmentation discussed. The data manipulations that are required to organize the transaction data into a convenient and usable data structure can require a significant amount of effort and computer time.² However, preliminary studies suggest that all data transfer (from the primary storage files to a PC) and manip-

ulation can be automated and accomplished during the evening hours so that data can be current. Using data that is at most one day old should serve as adequately as completely current data for the purposes of this study.

With the historical data being collected and manipulated on a timely basis, cost driver levels can be measured and costs can be calculated based upon historical experiences serving geographic market segments. By using historical data, management can base prices upon the costs actually incurred rather than what they wish they could achieve. However, on occasion there may be reasons, influenced by operational, customer, or other demands (as discussed later in this section), when management feels the historical data may not be the best basis on which to measure the cost of a shipment. Because of this, management will be allowed to override historical data when deemed appropriate.

Historical data can also serve as a basis for identifying existing pricing practices that need attention. This is an additional benefit of the DPDST, and will be discussed at some length in the sub-section addressing Operational/Marketing dimension page 147 and in the sub-section titled "Stage Four—Adding a Customer Dimension" on page 155.

Multiple Measurements

Since, as mentioned, cost measurement, and therefore price establishment, is influenced by many concerns, the ability to measure costs under varying operational options is critical to appropriate price establishment. In addition to the varying operational characteristics that can influence cost measurements, variance in anticipated cost driver levels, based on historical data or on special cir-

2. For example, one non-optimized test case took over 10 hours of computer time using a 486 66 MHZ PC.

cumstances, as dictated by management, gives rise to the need for the DPDST to be able to generate multiple cost measurements.

To illustrate the need for flexibility in estimating/measuring the cost of a proposed shipment, consider a given market segment from NY, NY to Cincinnati, OH. If management finds, upon investigation of its historical data, that for shipments in this market segment, the four primary cost drivers of linehaul time, linehaul distance, non-revenue time, and non-revenue distance all vary significantly from shipment to shipment, the question becomes immediately apparent of what the most appropriate value would be to use for calculating the cost, and therefore for price establishment of a proposed shipment. Is the mean appropriate, or are corporate mandated specifications more appropriate for this particular circumstance?

What if something unique to a specific customer or circumstance allows the carrier to feel confident that historical data should play a smaller role than usual? Are there other considerations in resolving this question? Suppose, for instance, that it is found that historically, drivers average 32 hours for the linehaul of the shipment from NY, NY to Cincinnati, OH. However, company rules-of-thumb suggest that it should only take 21 hours for the linehaul. Suppose further that the historical data reveals that more than 20% of the shipments had a linehaul time greater than 41 hours. Which value should be used? If management feels that the particular shipment being priced will take longer than usual due to customer requirements, it may choose to use the 41 hours in the measurement of price. If, on the other hand, management wishes to use a penetration pricing strategy, it may wish to use the 21 hours to measure costs in the establishment of a price.

In order to adequately address these questions, management must be able to measure costs based on varying levels of each cost driver, whether it be high, low, the median, or some other number. This will allow management to set the price most appropriately for the given circumstance. Because of this, the DPDST allows the flexibility to include multiple cost measurements so that the cost most appropriate for a given situation, (not solely for a given market segment) can be chosen.

It should be noticed from the preceding examples that variance in cost measurements can come from three distinct sources, 1) varying cost driver levels, 2) changing operational characteristics and 3) varying corporate strategies. Each of these cost variance sources needs to be treated distinctly. Therefore, cost measurement in this DPDST incorporates the ability to recalculate costs under an unlimited combination of various influencing factors. Varying cost driver levels will be dealt with by giving DPDST users flexibility in measuring the costs of a proposed shipment.

In practice, multiple, strategically or operationally motivated, distinct cost measurements may be desired. It is likely that management may wish to measure costs over a particular lane using a particular set of criteria. It may wish to measure costs for a particular customer distinctly. A default costing method for front-line personnel may be desired. The possibilities seem endless.

The DPDST includes the ability to measure costs virtually instantaneously in any defined manner. The measured costs can vary due to differing strategic choices, varying operational choices or varying cost driver levels. The user will be able to base the measured costs on historical data or on user-provided cost driver levels. When using historical data, management will be able to base costs upon any grouping of the data it wishes. For example, it can use averages, low

measured values, or high measured values. It can filter the data to be customer specific, time of year specific, or day of week specific. In this manner, management can perform sensitivity analyses in real time and can measure costs in appropriate manners on a case by case basis.

Activity Based Costing and EVA

All cost measurements performed by the DPDST use ABC techniques, with the primary cost drivers being linehaul distance, linehaul time, non-revenue distance, and non-revenue time. Other cost drivers that play a smaller role include tax rates, interest rates on debt, and required returns on capital.

The role of time as a cost driver bears some discussion. A TLMC is able to generate revenues only when its power units are carrying revenue generating freight. Often it is the intention of management to allow drivers to work five days and to rest two days. This means that time measured activities must be compensated in the five revenue generating days. Therefore, as per time unit costs are generated, such as for debt or capital costs, their per time unit cost must be translated to a per revenue generating time unit.

For example, suppose that a debt of \$1,000,000 at 12% interest, to be paid back in a one year period, must be included in the measured costs. This would mean that all the debt should be paid for at the rate of \$1,120,000 per year (principal + interest) or \$3,068.49 per day.

However, the company may experience only five revenue generating days per week which would mean that the debt should be paid for in $5 * 52 = 260$ days, or \$4,307.69 per day. To spread the time based costs over a calendar year would under-measure these costs and would give a lower than appropriate cost measurement which could in-turn lead to lower than appropriate prices. Therefore, care must be taken as such costs are calculated.

Several costs need to be measured in a special manner and will be included as special costs since they cannot be measured as a simple function of historically captured transaction data. For example, fuel prices should be measured on a state by state basis and by season. Therefore, cost measurements will have the ability to incorporate these seasonally adjusted, state by state measurements for fuel and fuel taxes. Similarly, federal taxes, FICA, and employee taxes will be included as special items that are not a simple function of linehaul distance, linehaul time, non-revenue distance, or non-revenue time.

Capital costing or EVA will also be incorporated into the cost measurements. There are occasions when management may wish to employ a penetration pricing strategy and disregard some capital cost allocations or corporate sunk costs. Therefore, the cost measurements section of the DPDST must allow management to include or exclude any or all special costs as circumstances dictate. Finally, this ability to include or exclude these special cost categories must be dynamic in order to allow management to perform multiple cost measurements dynamically. This allows sensitivity analyses on costs to determine the degree of subsidization required to penetrate a market.

Managing the Costing Flexibility

With the extreme flexibility described, management must use care when performing multiple cost measurements on a single geographic market segment. It would be easy to play with distinct measured costs until one was found to fit preconceived notions or prejudices. The underlying purpose of the cost measurements must always be kept in the forefront, this being that prices ultimately must cover costs and to keep the company viable. In conjunction with this, one of the purposes of measuring costs in setting prices should be to set lower limits on a price. If it is found that historically, costs have been higher than revenues

for a certain geographic market segment, making that segment unprofitable. management should be willing to abandon the business if it cannot be improved or if it is not tied into other profitable and compensating business. The purpose of measuring costs should not be to justify the continuation of inherently unprofitable services.

Utilizing costs as described is the first step in the development of the DPDST. This initial step is outlined in figure 18. Notice that the third step in the flowchart calls for the "most appropriate statistic" to describe the historical data for this cost measurement. This most appropriate statistic might be an average, a mean, a mode or some other statistic. The ability to identify this most appropriate statistic will be discussed in the sub-section on incorporating graphical views.

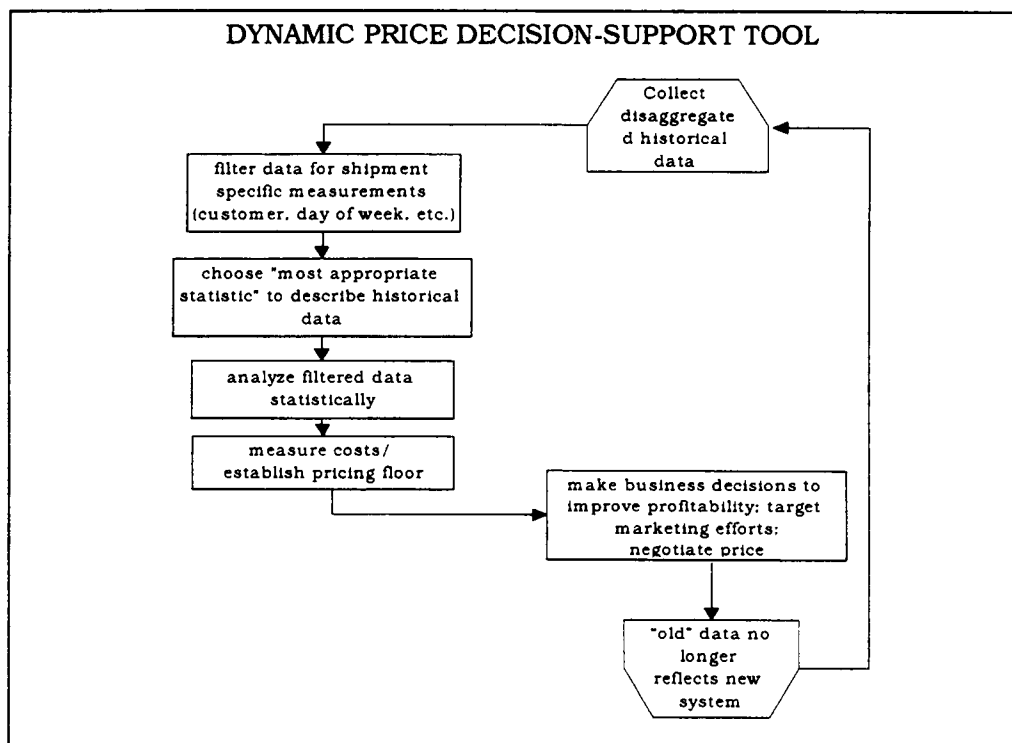


FIGURE 18 The Construction of a Flexible Costing Model

Stage Two—Adding the Demand, Value of Service, and Competition Dimensions

Once a cost measurement has been established in isolation of other pricing dimensions, the DPDST will allow the user to consider the impacts of demand, value of service, and competition on price. Measurements of competitive pressures are not readily available in publicly available databases. However, these pressures are typically known to practitioners in the field through everyday experiences. The intuition that these everyday experiences bring must not be disregarded, but rather must be properly balanced with all other dimensions in the DPDST.

Measurements of demand and value of service, on the other hand, can be estimated from data in the historical transaction databases. These measurements are not perfect since sales do not correlate perfectly with demand or value of service. However, this readily available data can be used as a close approximation, and needs to be considered in conjunction with the previously discussed cost measurements to properly set prices.

The information that is embedded in historical databases that should be considered are historical prices and the variance of historical prices. Historical prices are not shown in isolation as absolute numbers using company-wide averages, but rather are presented in a variety of ways, using disaggregated data specific to the pricing situation (the particular market segment) being considered. Averages are used but do not dominate the attention of the user. The variability and trends of prices in the specific geographic market segment being considered are presented understandably and simultaneously with cost measurements so that they can be factored into the final price.

The historical prices provide a measure of demand and competitive forces since the transactions took place at the recorded prices in a competitive market. Ideally, the historical data is supplemented with management's knowledge of the competitive environment. Thus, the presentation of the historical data enhances the memory and understanding of management in setting prices. It also serves the purpose of removing variation from the decision-making process since all decision makers have instantaneous access to similar knowledge bases.

Thus, adding the dimension of the influence of demand/value of service and competition to the DPDST begins to add utility and precision to the system. The addition of this aspect is illustrated in figure 19.

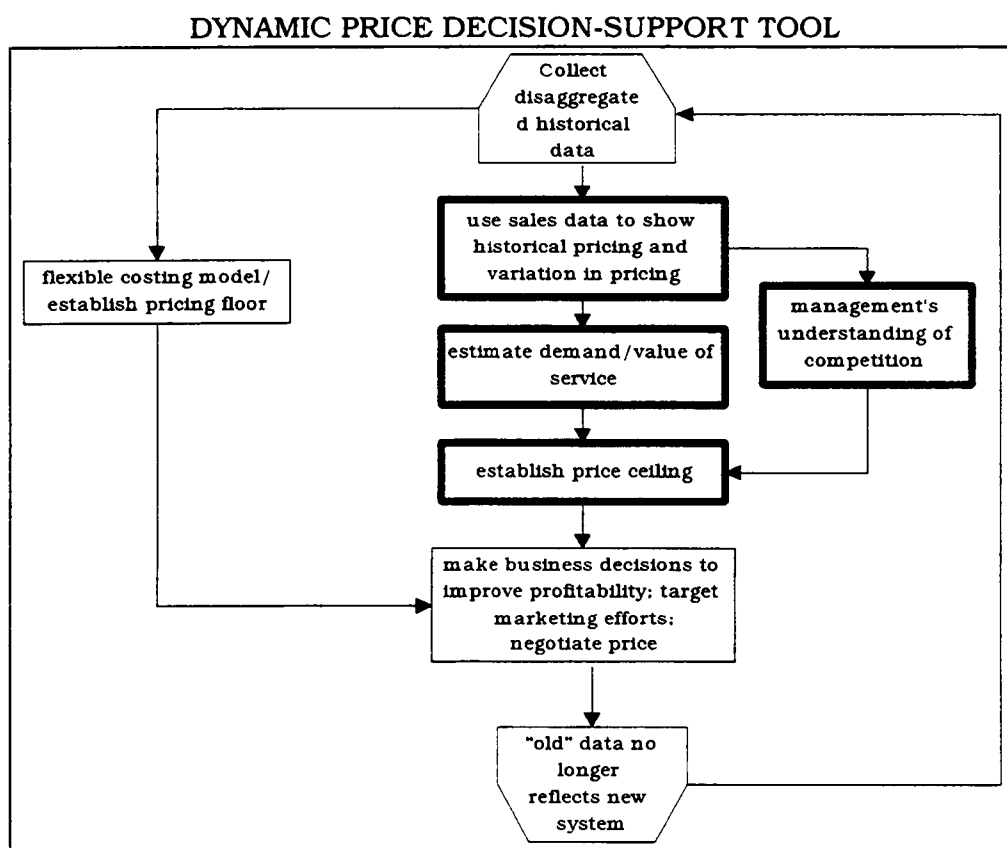


FIGURE 19 Adding Demand/Value of Service, and Competitive Dimensions to the DPDST

If the two stages presented, measuring costs and presenting historical prices as a measure of demand, value of service, and competitive forces, do not harmonize in establishing a price, an operational or marketing solution might be necessary. This is discussed in the next sub-section.

Stage Three—Adding an Operational or Marketing Impact Dimension

When existing business is shown to be priced below cost, it does not necessarily mean that the price must be raised or that the business must be abandoned. It may be that an operational solution can be found. If competitive pressures do not allow the price for a given market segment to exceed measured costs, the costs must be analyzed in detail. The market segment might be found to be unprofitable due to marketing or operation problems such as lane imbalances. Management might properly determine that the correct course of action would be to keep prices where they are but to make them profitable by changing the operational environment or refocusing marketing efforts.

In considering lane imbalances, the DPDST also assists the marketing department by manifesting lane imbalances so that specific areas can be targeted. As lanes are balanced, efficiencies are introduced and competitive pricing becomes easier. For example, location imbalances can be calculated by counting the number of pick-ups and the number of deliveries that occur at a given location. Similarly, feeder lanes can be identified for a given location by considering each truck that picks-up at a given location and identifying its previous revenue generating shipment.

These previous shipments can then be classified and counted to reveal information about the feeder lanes. Linehaul time can also be determined by cal-

culating the time between dispatch and delivery. Similarly, non-revenue time can be determined by calculating the time span from delivery to the next pick-up for a particular power unit. It should be noticed that cross-shipments which use more than one tractor on a single shipment need to be identified and treated appropriately.

Revenue and non-revenue distances are typically recorded directly. The only difficulty in identifying these distances is when they span more than one manifest. This occurs fairly often for operational reasons. (An informal study suggested that this occurs as often as 15%-20% of all transactions.) This difficulty can be overcome by segregating and recombining the data appropriately. The DPDST is able to do this in real time.

Historical prices of transactions over the geographic market segment being considered, as well as historical prices of shipments just prior to and just after the shipment, should be analyzed to determine if one of the shipments needs to subsidize another in an effort to maintain lane balance and equipment utilization. Therefore, the DPDST presents this information in real time in a form that expedites information utilization.

An example of how the information regarding previous shipment information might appear is given in the following screen captured table from the DPDST prototype (figure 20). This screen contains seven columns and ten rows. Each row contains information about a "secondary" geographic market segment that "fed into" the "primary" geographic market segment currently being studied. The secondary market segments or rows are ordered by how often they have been served. The seven columns contain the following information:

1. the average distance from the previous destination (secondary market segment) to the current origin (primary market segment),
2. the origin of the secondary market segment,

EMPTY MILES	PRE ORIGIN	PRE DEST	COUNT	LH Miles	LH Rev	LH R / Mile
0	Marion, OH 43302	Olive Branch, MS 38654	17	636	\$730.81	\$1.15
53	Dallas, TX 75244	Memphis, TN 38118	7	458	\$350.00	\$0.76
52	Bensenville, IL 60105	Memphis, TN 38118	4	543	\$600.02	\$1.11
46	Piney Flats, TN 37686	Memphis, TN 38194	3	491	\$633.59	\$1.29
23	Romulus, MI 48174	Memphis, TN 38118	3	707	\$813.05	\$1.15
20	Mena, AR 71953	Memphis, TN 38118	3	266	\$425.00	\$1.60
23	Portland, ME 04100	Memphis, TN 38118	2	1,392	\$1,461.60	\$1.05
23	Middletown, PA 17057	Memphis, TN 38118	2	925	\$838.11	\$0.91
23	Atlanta, GA 30331	Memphis, TN 38118	2	405	\$500.00	\$1.23
23	Lavonia, GA 30553	Memphis, TN 38106	2	687	\$830.67	\$1.21

FIGURE 20 Presentation of Previous Shipment Information

3. the destination of the secondary market segment,
4. the number of times the secondary market segment has been served,
5. the average linehaul distance of the secondary market segment,
6. the average revenues of the secondary market segment, and
7. the average revenues per linehaul mile of the secondary market segment.

If it is determined that a price for a shipment in a given geographic market segment can not be changed due to competitive forces, the information on shipments just prior to and just after that shipment can be utilized to improve operational or pricing balance to the overall system.

In utilizing the information provided by the DPDST to help determine price, management might determine that marketing or operational solutions to a lack of profitability for a given geographical market segment should be used. For example, drivers may be taking longer on the linehaul drive than is deemed appropriate.

This excess time can occur for a variety of reasons. For instance, single drivers need to rest eight hours for every ten hours driving by law. What if the ratio of rest time to driving time becomes too large? What if some shippers keep

drivers loading or unloading an excessive amount time? These problems are operational in nature and may need operational solutions rather than higher prices.

The company might choose to increase efficiencies which facilitate competitiveness. For example, if excessive linehaul time precludes the shipment from being profitable, using team drivers might solve the situation.

If shippers are delaying drivers excessively during loading or unloading, management may decide to use more trailers and drop the trailer off at origin or destination and pick-up the trailer at a later, more convenient date. If non-revenue time after delivery is a large problem in some geographic market segments, management might wish to use owner-operators and allow them to free-lance with other carriers so that they would be willing to take loads that are undesirable when the company uses its own equipment. (If owner operators are allowed to seek freight from multiple sources after the freight is delivered, they, potentially, have a much larger network than the motor carrier.)

The DPDST allows costs to be measured differently from one operating situation to the next. Take for example, the comparison of costs of using team drivers versus single drivers. These comparisons require fundamental changes in how costs will be measured. Some of the differences in cost measurements of team drivers versus singles might include a labor cost of \$0.35 per mile and \$0.12 per mile for benefits for teams while single drivers would require only \$0.30 per mile and only \$0.06 per mile for benefits. These differences would, in turn, influence tax costs.

The trade-offs that might inspire management to consider such a comparison could be the decreased capital costs (due to decreased linehaul driving time) and decreased driver retention and retraining costs associated with team driv-

ers. The following demonstrates some of the changes required to convert from a team driver cost measurement to a cost measurement using single drivers.

Suppose that a company is considering setting-up a run from Olive Branch, MS to Phoenix, AZ (a market segment already being served by single drivers) using team drivers. Several elements will need to be factored into the analysis before an informed decision can be made.

First, the company needs to calculate the anticipated driving time for the linehaul using team drivers. The driving time should be noticeably smaller than with single drivers. The reduced linehaul time is the primary trade-off to be considered.

Single drivers currently are averaging 51.27 hours to drive the linehaul of 1457 miles. Calculations suggest that team drivers could make the same run in only 34 hours. The primary trade-offs are 34 hours for two drivers versus 51.27 hours for only one driver. With no other changes, the cost translates to \$1.20 vs. \$1.18. However, utilizing team drivers might force marketing efforts to decrease the non-revenue distance and time from its current levels of 106.45 miles and 19.85 hours.

If these non-revenue cost driver levels are reduced by half, the cost to use team drivers is reduced to \$1.10. This cost level allows a more efficient operation, greater profits, and if appropriate, lower prices. The reduced non-revenue activities could not be duplicated for single drivers because of the needed time for rest.

As alluded to earlier, another less significant difference between using teams versus single drivers comes from driver retention. Driver retention is noticeably better on team runs due to greater predictability of schedules by the drivers. This suggests that marketing might focus its efforts on establishing

more business from Phoenix, AZ to Olive Branch, MS to balance the lanes which could lead to improved efficiencies through the use of team drivers.

This type of scenario comparison is a necessary and integral component of the DPDST. To automate these calculations, the reduced driving time, driver retention costs, etc., associated with using team drivers should be spontaneously calculated and incorporated into the new cost measurements whenever the user wishes to measure the costs of serving a market segment using team drivers.

Notice that a spreadsheet could be set up to measure the costs of both operational methods of serving the market segment in the example given. In fact, both measurements could be accomplished very naturally with a spreadsheet using three dimensions. Figure 21 illustrates the process involved in creating such a spreadsheet.

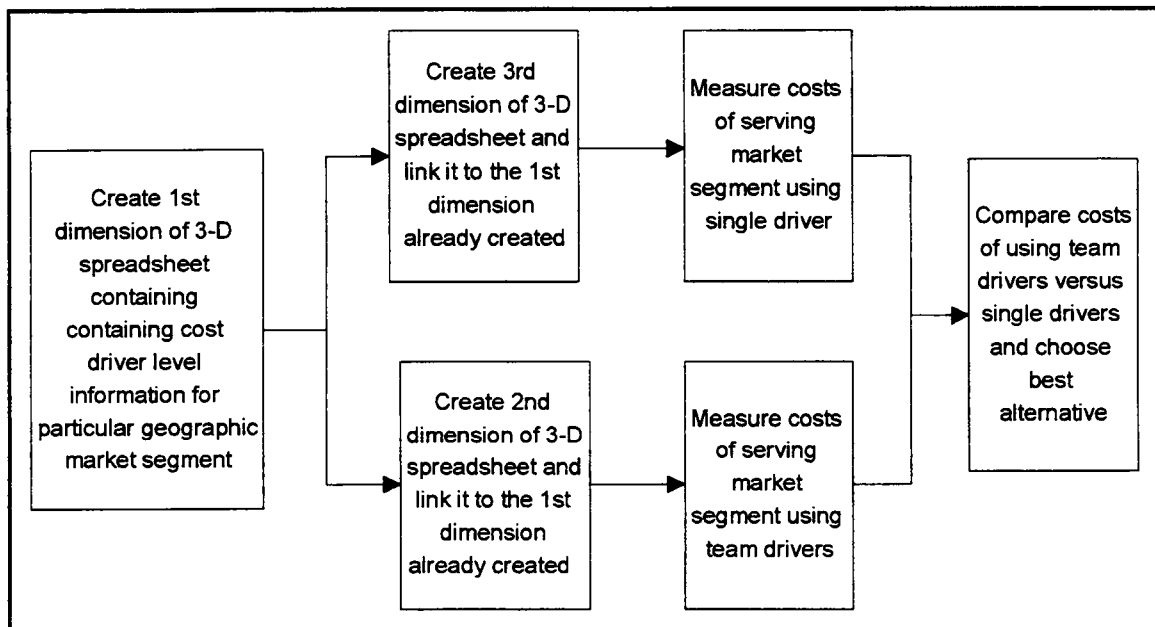


FIGURE 21 Process to Create a 3-D Spreadsheet Showing Effects of Choosing Alternate Cost Drivers

For example, suppose that the first level of the spreadsheet contains the cost driver information such as linehaul distance, linehaul time, non-revenue distance, non-revenue time, tax rates, capital costs, etc. The second level of the spreadsheet would use the data from the first level to measure the costs using team drivers. The third level of the spreadsheet also would use the data from the first level to measure the costs of using single drivers. Figure 22 illustrates how such a spreadsheet might look when implemented.

It will be immediately apparent that this layout requires that the distinct cost driver levels must be calculated and input by hand. The DPDST automates this step allowing management to dynamically compare the costs. Further, the DPDST allows comparison of an unlimited number of competing operational

DPDST					
	A	B	C	D	E
1	ORIGIN	Olive Branch, MS 38654			
2	DESTINATION	Phoenix, AZ 85000			
3					
4		single drivers		team drivers	
5	Linehaul distance:	1457.00	miles	1457.00	miles
6	Linehaul time:	51.27	hours	34.00	hours
7	Non-revenue distance:	106.45	miles	53.23	miles
8	Non-revenue time:	19.85	hours	9.93	hours
Cost Drivers					
DPDST					
	A	B	C	D	E
1				Total	LH
2	Variable Costs				Non-Rev
3	Labor	0.35	* distance	528.58	509.95
4	Benefits	0.12	* distance	181.23	174.84
5	Fuel	0.85	* distance	1263.69	1238.45
6	Fuel Taxes	0.18	* distance	271.64	262.26
7	Fixed Costs				
8	General Administration	0.06	* time	2.64	2.04
Team Drivers					
DPDST					
	A	B	C	D	E
1				Total	LH
2	Variable Costs				Non-Rev
3	Labor	0.31	* distance	484.67	451.67
4	Benefits	0.08	* distance	93.81	87.42
5	Fuel	0.85	* distance	1326.93	1238.45
6	Fuel Taxes	0.18	* distance	281.42	262.26
7	Fixed Costs				
8	General Administration	0.08	* time	4.27	3.08
Single Drivers					

FIGURE 22 Spreadsheets Comparing Team vs. Single Drivers

options without the hours of analysis previously required when the data had to be collected "by hand".

The setting of prices requires a dynamic and harmonious relationship between operations, marketing, and pricing. Each influences the other. The DPDST facilitates the inclusion of operation's influence on pricing so that profitable prices can stay competitive. The DPDST with this dimension added is illustrated in figure 23.

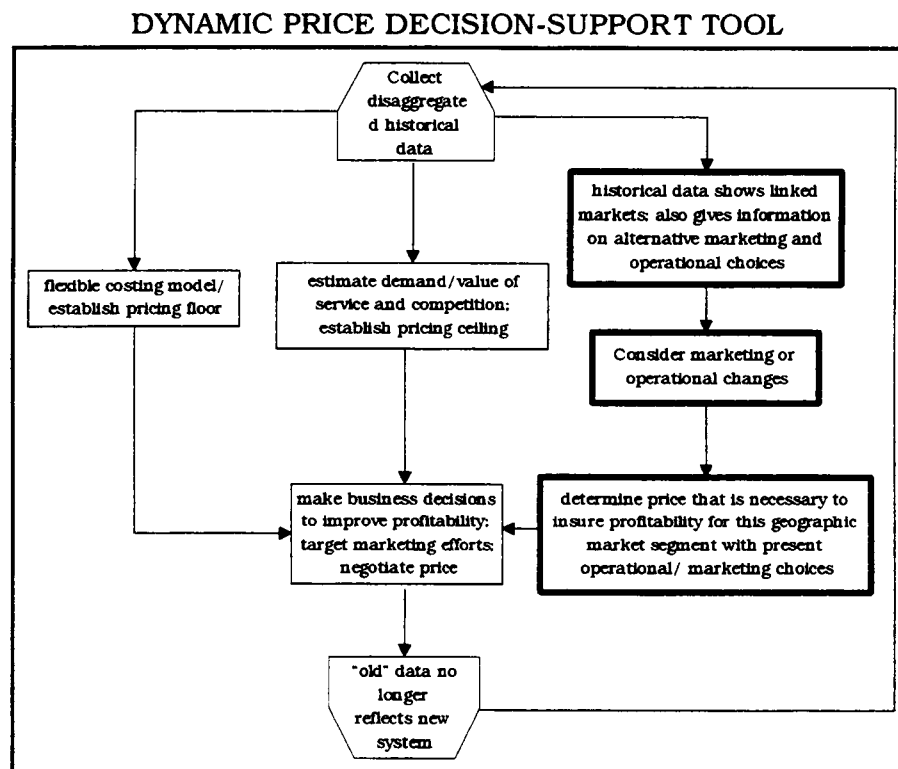


FIGURE 23 DPDST with Operations/Marketing Dimension

Stage Four—Adding a Customer Dimension

It is very possible that customer satisfaction efforts and profitable pricing efforts will be at counter purposes. This is not always desirable. Customers can be seen as a company's most valuable asset. But how should management harmonize the conflicting pressures of customer satisfaction and profitability?

To some extent, management must define "good customer." Is a good customer measured by revenues, longevity, profits, or some other means? If a customer is inherently unprofitable, it may not be a desirable relationship unless the unprofitability can be justified or rectified. However, it is more common for a particular customer to send profitable shipments on some route but not on others.

Because many shippers or customers request or demand that carriers haul shipments over collections of geographic market segments, carriers are seldom free to "cherry-pick" the most profitable freight while leaving the "dogs" for other carriers. Carriers must therefore look at the overall profitability of a customer, rather than looking at only the profitability of the customer restricted to a fixed geographic market segment.

The ability to identify profitable customers or potentially profitable customers is just one step in factoring in customer influences on price. Another influence would be the ability to negotiate. If the customer (shipper) is intent on developing long term relationships and building partnerships, then the information from previous stages can be shared with the shipper appropriately to demonstrate the justification and need to set certain rates. Certainly the information provided in the previous stages might aid negotiations with selected customers. Also, shippers may set-up relationships with other shippers to help balance

lanes once they understand the influence that these efforts have on their efforts to build partnerships and on their final shipping cost.

With the addition of the customer dimension, the DPDST comes closer to completion. This is demonstrated in figure 24.

Stage Five—Adding Graphical Views of Pertinent Historical Data

A fifth important dimension of the DPDST is the ability to view historical data and cost drivers graphically in order to factor appropriately the variation that the company experiences in its historical data. To take full advantage of the information that is presented by the DPDST, much of the information needs to be presented in a revealing manner to allow management to clearly understand the driving forces behind the system's suggestions. Histograms and time series X-Y graphs form a powerful method of communicating this information so that management can quickly determine trends and driving forces.

For example, to know that historical prices on a given geographic market segment had an average per revenue mile price of \$1.14, a low per revenue mile price of 1.07, and a high per revenue mile price of \$1.29 may not be sufficiently revealing for management to comfortably make a pricing decision. However, if a time series graph showed that a marked trend of rising prices existed, this could prove quite influential in the decision-making process. Similarly, histograms can provide important pieces of information as they expose the variation or spread contained in the data that leads to suggestions and decisions.

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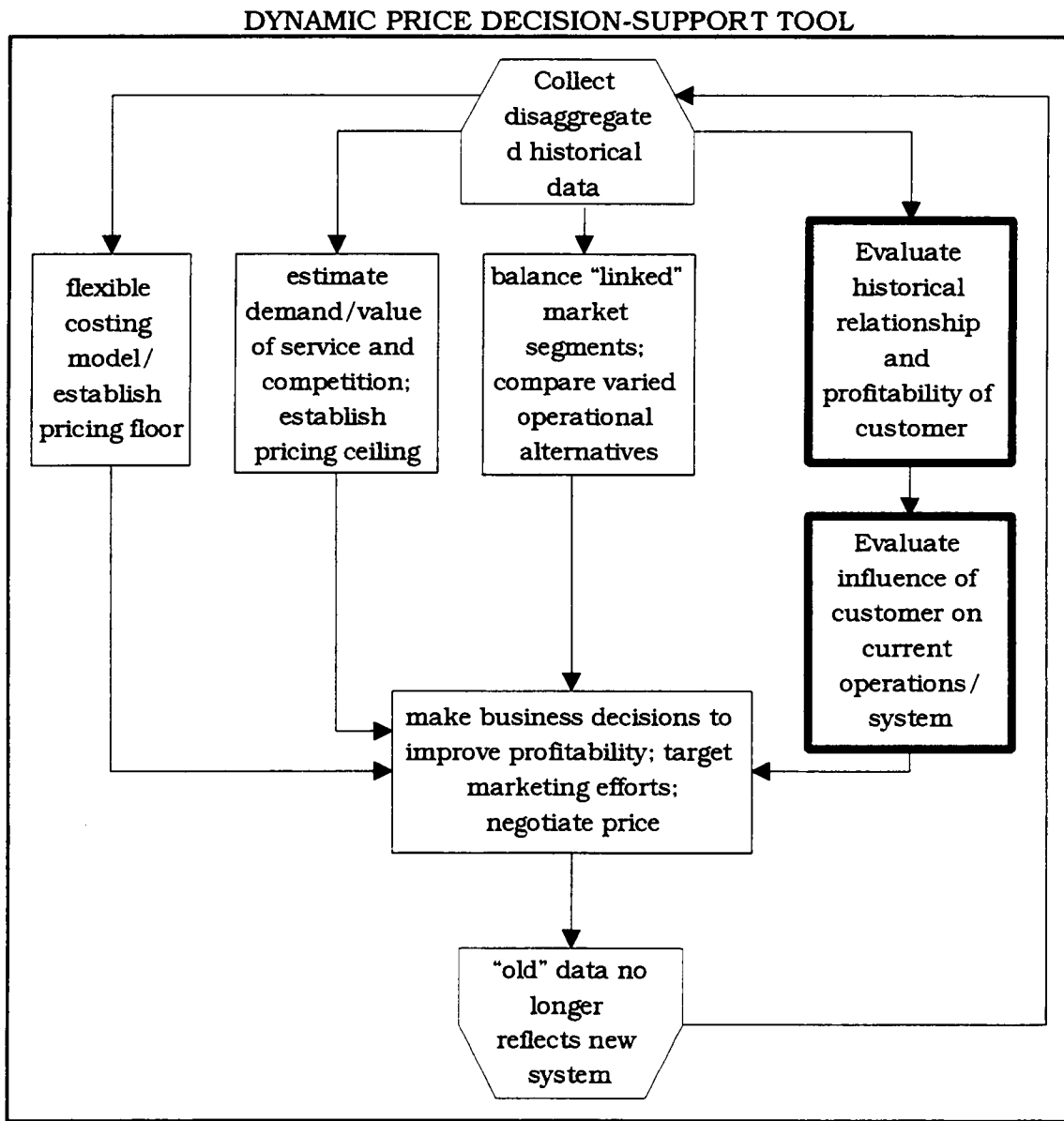


FIGURE 24 The DPDST with the Addition of Customer Influence

revealing for management to comfortably make a pricing decision. However, if a time series graph showed that a marked trend of rising prices existed, this could prove quite influential in the decision-making process. Similarly, histograms can provide important pieces of information as they expose the variation or spread contained in the data that leads to suggestions and decisions.

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These histograms and time series X-Y graphs should help management decide when sensitivity analyses are in order and when operations are out of control. If the variation is large on a given factor, using average values may not be appropriate for a particular price. Therefore, these graphs will be instantaneously available at all times. The following scenario, using sample data from a mid-sized TL carrier, gives an example of how management might use the graphs in the decision-making process.

Suppose that a company is trying to establish a price from Olive Branch, MS (a suburb of Memphis, TN) to Phoenix, AZ, and the DPDST suggests that they should charge \$1.24 per mile. However, historically shippers on this lane have never been charged (during the time period represented in the historical database being used by the DPDST) less than \$1.32 per mile. In fact the DPDST shows that the average price has been \$1.33 and the company has charged as

much as \$1.40 in the past. Management wishes to investigate to determine why the suggested price which is a fully allocated cost including taxes and capital costs is so much lower than historical prices. The first thing that is done is to look at the spread of the revenues as contained in a histogram. This histogram is shown in figure 25, part a.

This graph suggests that the same price is being charged very consistently. The few high charges do not appear to occur very often and might be customer specific. However, there might be a trend that shows a recent price increase so management might look at the time series graph, figure 25, part b.

This graph shows that towards the early part of the time period, a few unusual events occurred, but otherwise the price has been very consistent. This fact strongly suggests that management might wish to investigate further why the discrepancy exists between suggested price and historical prices.

A look at the histogram of non-revenue generating time, figure 25, part c, perhaps reveals the answer. The suggested price uses an average of 19.85 hours of non-revenue hours per shipment in its calculations. However, the histogram of non-revenue hours shows that there is considerable variability, which management could consider as an uncomfortable risk.

What is the suggested price if management bases its cost measurements upon the average value from the second lowest quantile shown in the histogram rather than the overall average? Management may prefer this value to assure that a greater percentage of the shipments are profitable.

The average value of the next lowest quantile is 36.43 hours, a significant increase over the 19.85 overall average. The suggested price is now \$1.36, \$0.03 higher than the \$1.33 average historical price.

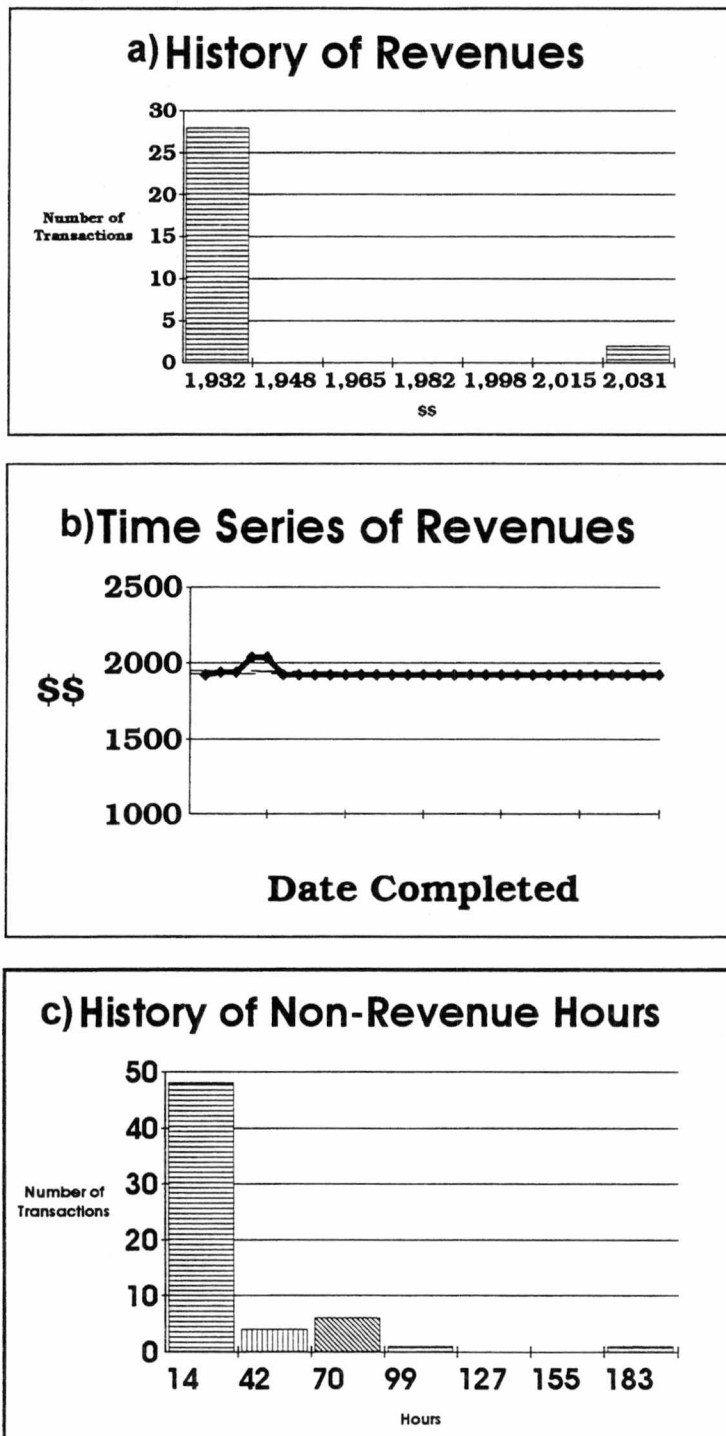


FIGURE 25 Graphical Views of Data:
a) Histogram of Revenues, b) Time Series Graph of Revenues,
and c) Histogram of Non-revenue Hours

It appears that management has felt greater than average uncertainty or risk with this geographic market segment and has chosen to use a non-revenue generating time measurement that assures profitability in all but the few extreme cases (only 10 of the 60 observed data points fall above the range used in the measurement from the second quantile) in their measured costs and their prices. Perhaps a \$0.03 price increase should be considered.

Finally, if management uses company rules-of-thumb on the linehaul time instead of historical data (substituting the length of time management expects the shipment to take, rather than the higher number represented by the historical average), the suggested price is only \$1.21. But, if this linehaul time rule-of-thumb is used along with the average non-revenue time from the second lowest quantile, a suggested price of \$1.33 per mile results. This price coincides precisely with historical averages. It appears that historically, management has added \$0.12 per mile to the expected cost of \$1.21.

Since management successfully charged \$1.33 in the past, there is no apparent competitive reason to lower prices and the price does appear to be rational so the original suggestion of \$1.24 should be disregarded in favor of historical prices averaging \$1.33.

Before settling on the price of \$1.33 per mile, another influencing factor that management might wish to consider would be the imbalance information at the destination. Since, for the sample company providing this data, Phoenix, AZ is located far from the established lanes normally served, it is quite difficult to solicit revenue generating shipments that return equipment into desirable lanes. Upon being examined via the DPDST, imbalance information shows that this company has delivered 121 shipments into this area while only picking up 56

shipments in this area during the same time period. This explains why there is so much non-revenue time associated with this geographic market segment.

Finally, management may wish to consider if it can successfully generate profitable business after arriving in Phoenix, AZ. Looking at successive moves historically, and at their profitability reveals the following information. (Again, this is facilitated by the DPDST. With minimal effort, the DPDST produces table 7 in real-time, with current company data.)

TABLE 7

Shipments that Occur after Delivering in Phoenix, AZ
(listed in decreasing order of frequency)

Origin	Destination	Cost	Price
Phoenix, AZ	Lakewood, NJ	\$1.07	\$0.96
Phoenix, AZ	Atlanta, GA	\$1.10	\$0.80
Phoenix, AZ	Olive Branch, MS	\$1.02	\$0.85
Tolleson, AZ (a suburb of Phoenix)	Memphis, TN	\$1.05	\$0.96

It will be noticed that the company is losing between \$0.09 per mile and \$0.30 per mile on these return shipments. A weighted average yields an average loss of \$0.1747 per mile. This suggests that the price that is being charged on the shipment from Olive Branch, MS to Phoenix, AZ should be \$0.17 or \$0.18 higher than the original suggested price or measured cost produced by the DPDST, instead of the \$0.12 mentioned above that has been added historically to compensate for the loss that occurs on the backhaul, meaning that there is a (\$0.05 or) \$0.06 per mile loss on the linehaul and backhaul combined.

The carrier may want to consider raising its price. This price increase should occur and could be allocated to the successive backhaul shipments, to

this linehaul shipment, or divided among the shipments in some way. If this price increase is combined with the earlier suggested price increase (of \$0.03) due to excessive variability or risk associated with the non-revenue generating time, the price increase is raised \$0.09 per mile, which may not be competitively possible to charge.

If the market will not allow even the \$0.06 per mile increase, then marketing should search for more profitable backhaul customers or management should consider abandoning the business. However, before management decides to abandon the business, it should understand that \$0.20 per mile of its costs come from capital costs. The shipment is covering its out-of-pocket costs and contributing something towards capital costs. It's just not covering its fully allocated capital burden. It is conceivable that the business could still be desirable in the overall network due to customer and capacity utilization needs, in spite of the fact that it does not cover all costs.

As the above example illustrates, the graphical abilities of the DPDST greatly facilitate management analyses of current pricing strategy, and significantly assist with pricing. This stage (of adding graphical views of pertinent historical data) is extremely important to the utility of the DPDST. Figure 26 shows how the components discussed to this point combine to yield an abridged DPDST.

DYNAMIC PRICE DECISION-SUPPORT TOOL

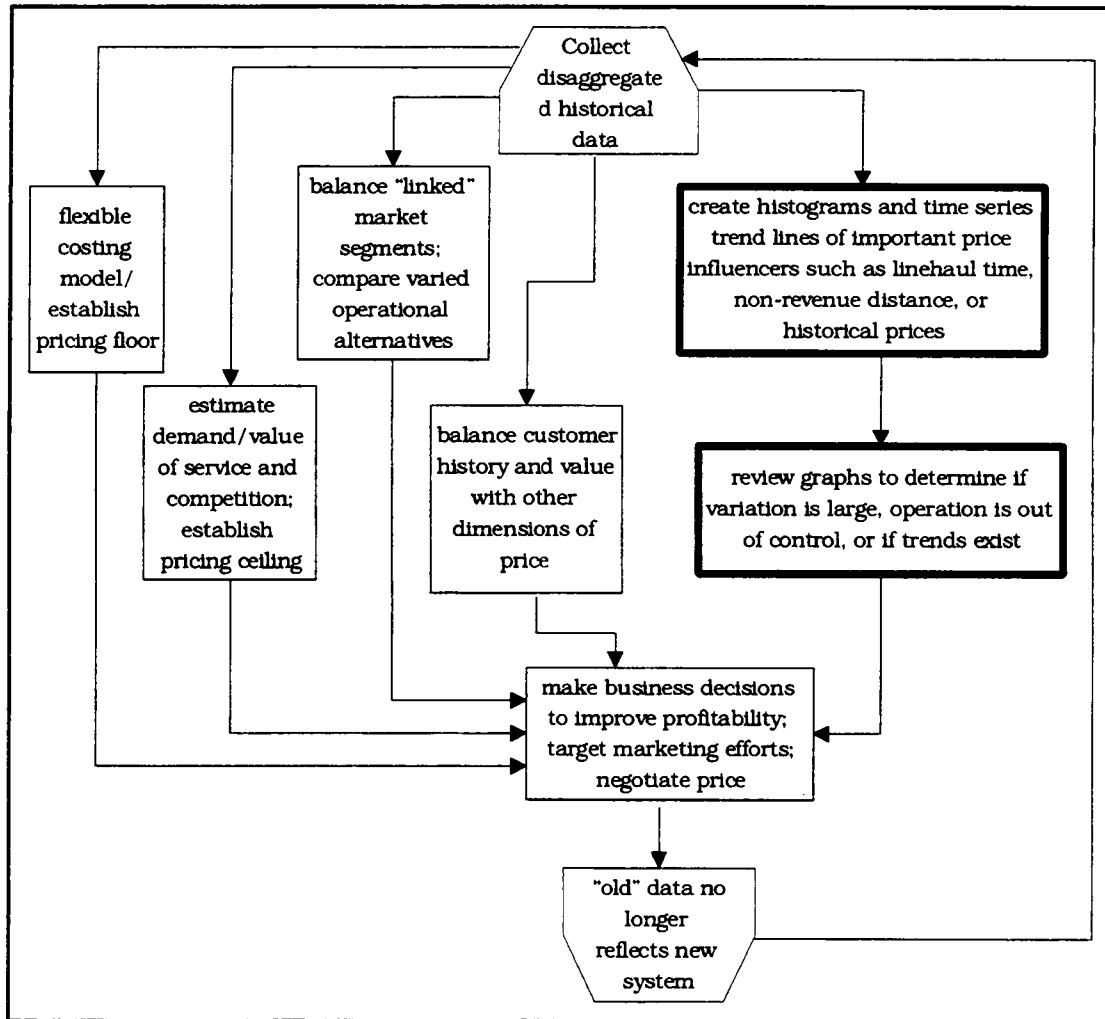


FIGURE 26 DPDST with Addition of Graphical Views

Stage Six—Adding a Corporate Objective Dimension

The final phase in the development of the DPDST is to add the influence of corporate objectives. These objectives should influence prices and offers, can vary from market segment to market segment, and may vary over time. For example, corporate objectives may be to set prices high enough to cover totally allocated prices on established market segments only. The less established market segments might use a penetration pricing strategy with no attempt to cover sunk costs or capital costs. Other corporate objectives or strategies might be operational in nature. For example, management might decide to use team drivers on selected market segments to increase equipment utilization and driver retention. Still other corporate objectives might lead management to influence marketing's efforts to correct lane imbalances or to strengthen relationships with selected customers.

Any of these objectives should influence price. Notice that management's abilities to make such strategic and tactical decisions are expanded by the wealth of information that has been provided by the previous stages. For example, the ability to penetrate a market segment is influenced by the ability of the company to compensate for the sunk and capital costs to which the new market segment does not contribute.

The following example will demonstrate how corporate objectives might influence price. In the preceding discussion of the graphical abilities of the DPDST, a price was suggested for the Olive Branch, MS to Phoenix, AZ geographic market segment. It was determined that the price should be increased by \$0.06 to \$0.09 per mile. Much of this suggested price increase was due to the traffic that occurs after delivering in Phoenix, AZ.

It should be noticed that the Tolleson, AZ to Memphis, TN geographic market segment comes the closest to making a full contribution of all the geographic market segments served. This suggests that management might wish to exert its marketing efforts to increase its presence on this lane. Traffic could then be diverted from the less profitable lanes such as Phoenix, AZ to Atlanta, GA or Phoenix, AZ to Olive Branch, MS.

It should also be observed that significant traffic travels in both directions, from Olive Branch, MS to Phoenix, AZ and back. An investigation of using team drivers instead of single drivers suggests that a profitable price would probably be about \$1.03 per mile in each direction assuming that non-revenue time between shipments was only three to four hours. If the average price charged were \$1.03 per mile on this circuit, the circuit would be fully profitable. Since prices already exist that average $(\$0.85 + \$1.33) / 2 = \$1.09$ per mile on this circuit, the prices could be left unchanged and the company would experience increased profits if it could attract enough traffic to use team drivers on this pair of geographic market segments.

Management may wish to exert marketing efforts in order to establish team drivers on this circuit. This could reduce the overall need to raise prices on this market segment by offsetting some of the losses experienced by the non-team drivers on their shipments from Olive Branch, MS to Phoenix, AZ.

This further illustrates the point made in the last segment, that is, when the DPDST suggests that a market segment is not covering a totally allocated cost, it does not necessarily indicate that the market segment should be abandoned or that prices should be raised. Instead, management must decide if the loss should be continued for strategic or operational reasons.

This last stage of adding the influence of corporate policy into the DPDST completes the pricing suggestion system. Figure 27 combines all the components discussed so far and shows, in abridged form, the completed DPDST.

The Completed DPDST

When all aspects of the pricing system are combined, a fully operational and optimally useful Dynamic Pricing Decision-Support Tool is created. The system, in its fully expanded form, is graphically illustrated in figure 28.

Having completed the development of the DPDST, the first two objectives of this research are accomplished (see page 31). The following section will address the first research objective as it discusses the automation of the DPDST through the creation of a fully functional software prototype.

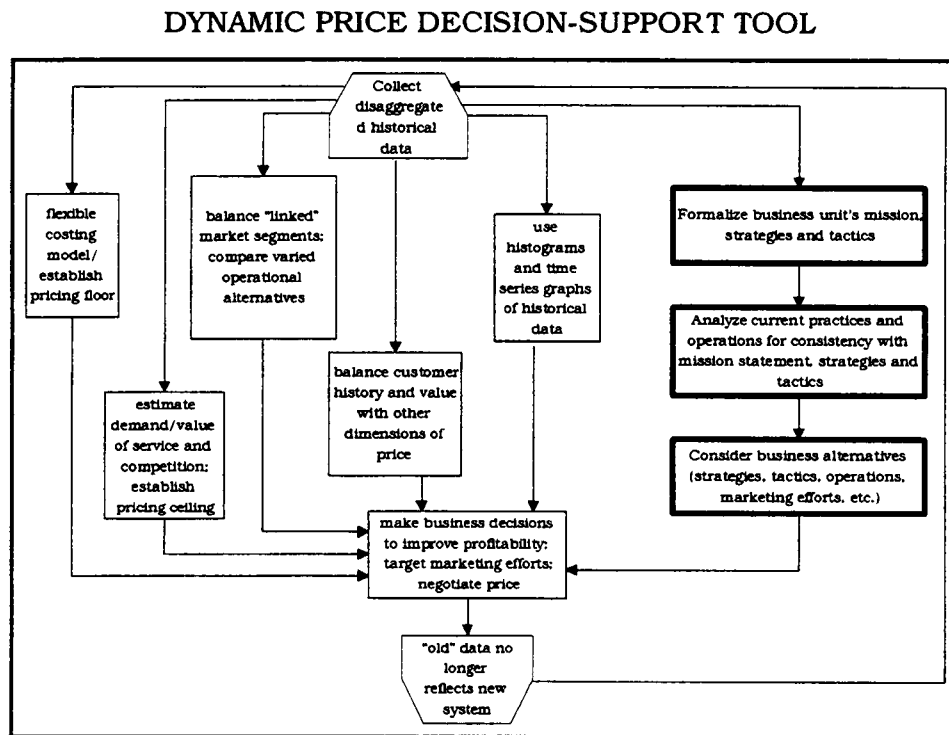


FIGURE 27 DPDST With the Addition of Concerns of Corporate Strategy

DYNAMIC PRICE DECISION-SUPPORT TOOL

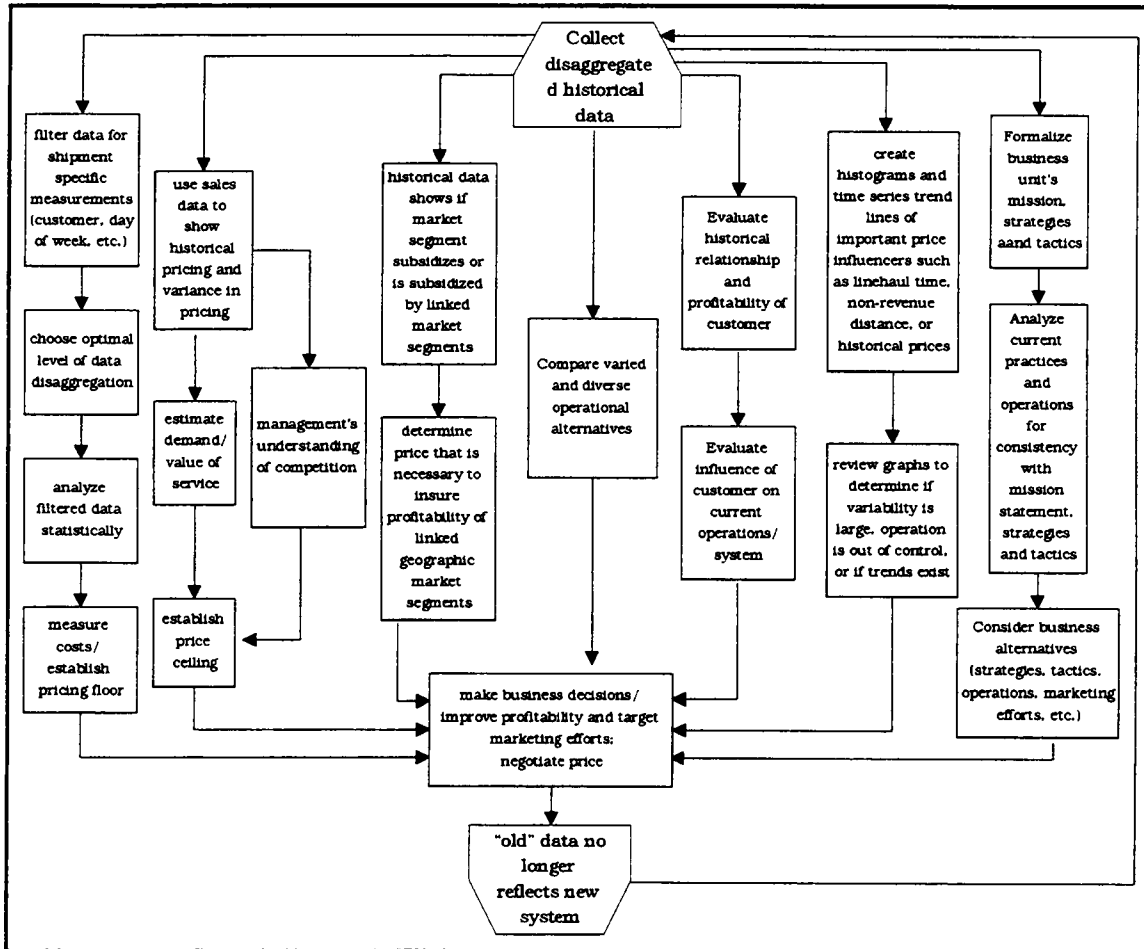


FIGURE 28 The Completed DPDST

Prototype Development

The development of the computer prototype of the DPDST closely approximated the development of the DPDST itself. The presentation of the prototype will chronicle some of the highlights that led to the final software version that was used in the validation of the DPDST. It will then describe the degree to which the prototype represented the DPDST.

The prototype development occurred in stages with modules added as industry partners and experts made suggestions and criticisms. The prototype was designed to be a fully functional and operational pricing suggestion system. However, in the beginning, the prototype did not incorporate all features of the DPDST. It was anticipated that some of the features of the DPDST would be more important to implement and include than others.

From the beginning, it was believed that ITS analysis of the data followed by its incorporation into a dynamic and interactive ABC costing system would be important. These were the first dimensions incorporated into the software prototype. The data included in the initial prototype also included information on historical prices and sales information, giving an estimate of demand and value of service, as discussed above.³

At first, management believed that the costing dimension would be adequate since practitioners maintained that they had a clear understanding of the rest of the dimensions of price due to their day-to-day experiences. However,

3. See page 145.

after many hours with upper-level management from the industry partners, it was determined that while the software was impressive and potentially helpful, it fell short of being a tool that could prove useful in day-to-day operations because of the missing dimensions of pricing not yet incorporated into the software. So additional aspects were added to the prototype.

The first addition, felt by industrial partners to be the most flagrantly missing piece, after their initial review, was a series of graphs to show and variation and time series trends. This led to the addition of the histograms and time series X-Y graphs of revenues, linehaul miles, linehaul time, non-revenue miles, and non-revenue time.

This version of the prototype received greater approval, but industry partners felt that it needed an even more complete incorporation of the features of the DPDST. So the abilities to view lane imbalances and information regarding transactions leading-up to the point of origin as well as transactions occurring after leaving the point of delivery were added.

After these capabilities were incorporated into the prototype, users felt that it captured enough of the essence of the DPDST to be usable in a real-world setting. Table 8 compares the DPDST with the final software prototype.

It will be noticed that the features of the DPDST that are most obviously missing from the prototype are strategic decisions, competition, and filtering data by customer. These omissions were done with forethought. The failure to include strategic decisions in the prototype was due to management's knowledge of their strategic motives without the aid of a computer program.

Competitive information was not included due to a lack of available data and the belief that historical revenues serve as a meaningful substitute. (As mentioned previously,⁴ historical revenues reflect prices that were successful in

TABLE 8

Comparison of DPDST with Software Prototype

Feature	DPDST	Prototype
Activity Based Costing	YES	YES
Capital Costs	YES	YES
Federal Taxes	YES	YES
FICA	YES	YES
Employee Taxes	YES	YES
Multiple Cost Measurements	YES	YES
Historical Revenues used as a measurement of value of service and demand	YES	YES
Market segment specific data	YES	YES
Time series analyses and graphs	YES	YES
Histograms of cost driver levels	YES	YES
Lane imbalance information	YES	YES
After delivery shipment information	YES	YES
Pre pick-up shipment information	YES	YES
Non-revenue information	YES	YES
Ability to measure costs using company rules-of-thumb	YES	YES
Day of week specific information	YES	YES—limited
Customer specific information	YES	NO
Includes driver retention & retraining costs	YES	YES
Includes accessorial costs	YES	YES
State by state fuel rates, fuel tax rates, and fuel efficiencies	YES	YES
Allows for use of multiple trailers in cost measurements	YES	YES
Includes standard cost items such as labor, equipment, general administration, etc.	YES	YES
Strategic decisions	YES	YES—manual
Competition	YES	YES—manual
System wide reports	YES	NO

4. See page 145.

a competitive environment, so this information does reveal something about competitive forces.)

Finally the lack of customer specific information was due to management's belief that most customer specific information was already captured since customers can usually be identified by geographic market segment. This led to the opinion that the prototype was a close enough approximation of the DPDST to act as a test vehicle for this study.

Technical Aspects of Prototype Development

Per the plan discussed in part III, the software prototype was programmed using the Windows 3.1 environment and Visual BASIC version 3.0 as the programming medium. It used standard GUI features and followed standard Windows® conventions. This facilitated the programming and reduced the learning curve for the industry partners as had been hoped.

Development of the prototype took place on two development machines. The two machines were used to emphasize to industry partners the relationship of the program to the data. The program was developed on one machine and the data was contained on a separate machine. The two development machines were networked together, allowing the program access the data files on the second machine. The program's initialization files contained pointers to the supporting database files, allowing the database files to be placed in any electronic location desired (even on different machines as in the development environment if desired).

A third machine (the "test machine") for the software was placed on-site with the industrial partners. This was a medium class PC (486, 33 MHZ with 8 MB RAM PC clone running DOS 5.0 and Windows 3.11). Both the program as well as the database files were placed on this machine. The prototype performed

adequately in this environment with no unexpected, unusual or glaring defects or time delays. The analysis times mentioned below were all measured using the test machine.

The development machines were of the same general speed class as the test machine (386, 40 MHZ with 8 MB RAM and 486 DX2, 50 MHZ with 16 MB RAM) to assure that the software ran similarly (speed and functionality) on all machines. Since the industry partners were located about 70 miles out of town, the ability to "experience their machine" while developing the program became increasingly important.

The presentation of the pricing suggestions and of the supporting background information on the computer screen of the prototype took some time to develop and required input from industry experts and industry partners. For an example of a screen capture showing a price suggestion using cost driver levels obtained from averages of the historical databases restricted to a specific geographic market segment see figure 30, page 187.

Non-DPDST Features

Some features of convenience, related more to program utility than directly to the DPDST were incorporated into the program. Some of these features were necessary to facilitate the adaptation of the DPDST from theory to software. Several other features were requested by the users of the program to increase "user-friendliness."

Because of the purpose of the software, no automated installation program was written. The program required that all necessary files be copied to the test machine from the development machines whenever an update occurred. The program initialization files required updating by-hand. This process of replacing older versions of the software with new versions occurred fairly frequently (there

were over six versions placed on-site with industry partners). Most updates were small in nature (such as eliminating programming bugs as they were found) and required no re-training of end-users.

Occasional difficulties and programming mistakes occurred as new versions of the software were developed. The graciousness of the industry partners was manifested when their time was spent to observe a program that did not function as promised. This only occurred once or twice and was due to video card incompatibilities between the development machines and the test machine. This incompatibility was rectified so that future upgrades did not suffer from the same problem.

Limited amounts of error trapping were included to increase the effectiveness of the program, and ultimately for the end-users' convenience. For example, when zip codes were input by end-users, they were compared against a database table containing all 5-digit zip codes. If the end-user typed in a zip code that was inappropriate, an error message appeared and the user was given another opportunity to enter the desired zip codes. This same type of error trapping was used in a number of places in the program such as for city names, state names, and number of accessorial stops. This served the purpose of assuring that the program functioned properly and understandably. Without the error trapping, it would have been easy to present price suggestions based on faulty premises due to typing errors. If these typing errors went unnoticed, prices might be negotiated based upon incorrect reasoning.

An additional feature that was incorporated was the ability to copy the analyses and graphs from the prototype to other software such as word processors via the Windows clipboard. This ability was built into the program as it was anticipated that the information gathered from the analyses might be gathered

into a report format for special purposes such as supporting materials for price negotiations or internal reports and audits.

One feature was specifically requested by the test users of the prototype to facilitate its implementation. Early versions of the software forced the user to identify geographic market segments using 5-digit zip codes. The ability to identify geographic market segments by city names was strongly desired. Further, the ability to review the historical data before or during the geographic market segment identification was considered important. This was a natural set of conveniences that did not have an analogue in the DPDST. However, the conveniences were necessary to implement the DPDST as completely as possible, and were added per the request of the users. One request of the industry partners was that a user manual be written. Users found it time-consuming to have to re-learn the program when they used it infrequently. Although this was a reasonable request, it was considered beyond the scope of this research, and will be addressed at a future date.

A limited on-line help file was included to assist users as they learned to utilize the prototype. It is of interest to note that the most time consuming aspect of teaching industry partners to use the software prototype was related more to teaching the process of using the DPDST than to teaching the use of the software itself. While practitioners found the system natural and appealing, the ability to analyze a price interactively from so many dimensions was a new experience and required some training. The implementation of the software was a small step in this process. Typically, users appeared comfortable with the software within one to three hours.

Database Development

A very important part of the DPDST prototype included the use and analysis of historical data. To facilitate this step while the prototype was under development, the industry partners shared, on several occasions, transaction data spanning several databases. It was necessary to reconfigure these databases into a format and structure compatible with the intended purposes.

The first step was to import the data from ASCII tabular format into dBase IV format. This was followed by many "stutter steps," as the data had to be "cleaned-up" before the system could be used. The "stutter steps" ranged from weeding out fake records in the data that were used by the industry partner for debugging purposes in setting-up their database, to filtering-out data with missing information.

The process was complicated mid-stream when the industry partners changed their data collection methods and format. However, this experience, while somewhat frustrating, proved useful in and of itself. It forced the research to clearly identify the specific data needed, as well as the process needed to transform the data from its naturally collected state to a format that could be used by the prototype. Algorithms and methods finally were developed that applied across the multiple systems.

Once the historical databases were set-up, the prototype was programed to search the databases and statistically analyze the pertinent data to suggest geographic market segment-specific prices. Ultimately, the process of searching the databases and performing the statistical analyses took between five and ten seconds, depending upon the specific geographic market segment being considered as well as on the power of the computer being used. A complete analysis as

described earlier in the DPDST development took between one and ten minutes, depending on the degree of detail desired.

The prototype incorporated modern information engineering design as the many database tables were related in many ways in order to yield the desired information. The most obvious and often used relationship was that between the transaction database table and a zip code database table. The zip code database table contained city, county, state, and zip code fields. The transactions included 5-digit zip codes for origin and destination. This allowed the software to look up the origin and destination cities and states in the zip code database table using the zip codes found in the transaction database table. This look-up is explained in figure 29.

Many such database table relationships existed. Another such relationship was that between the transaction database table and the geographic market segment distance table. This came in to play every time the program measured the cost of a transaction. The geographic market segment database table contained four fields: origin zip code, destination zip code, state and distance.

A record existed for every state that a truck passed through on any shipment. For example, if the shipment was from Olive Branch, MS to Phoenix, AZ, the truck would pass through 1) MS, 2) TN, 3) AR, etc. The distances that the truck drove in each state were as follows, 15 miles in MS, 25 miles in TN, 100 miles in AR, etc. The records from the geographic market segment database table for this shipment are shown in table 9.

With this information, the DPDST can look-up fuel rates, fuel tax rates and fuel efficiencies on a state by state basis. The total fuel cost is then measured on a state by state basis. For new geographic market segments that are not yet

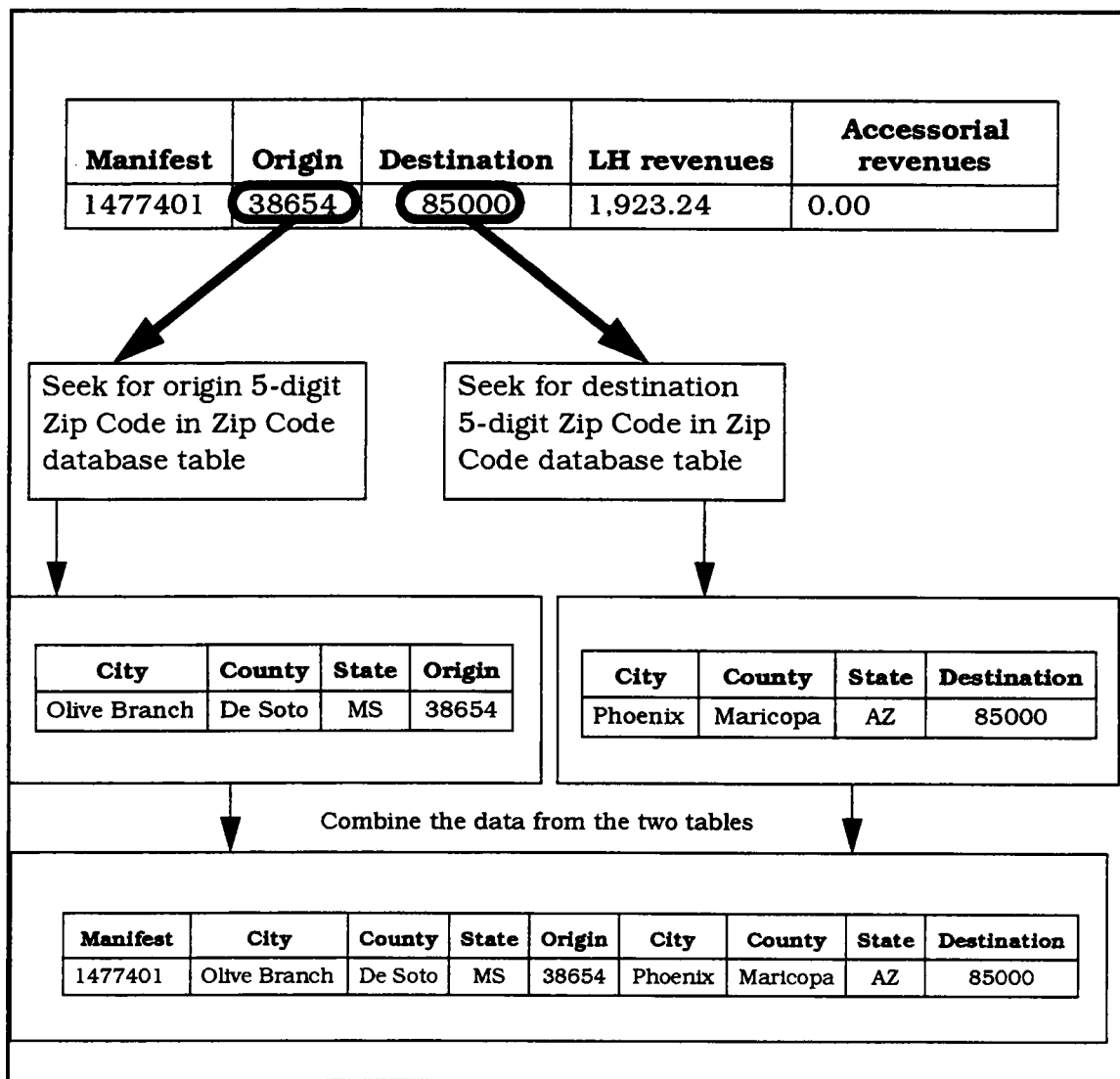


FIGURE 29 Look-Up Process, Cities and Zip Codes

TABLE 9Distances Traveled by State

Origin	Destination	State	Distance
38654	85000	MS	15
38654	85000	TN	25
38654	85000	AR	78
38654	85000	OK	67
38654	85000	TX	322
38654	85000	NM	125
38654	85000	AZ	100

entered into the above database table, the program automatically uses overall corporate averages across all states.

The prototype contained data access modules that allowed end-users the ability to alter selected database tables which were not linked to any historical transaction tables and needed manual updating. Examples of these tables were the capital costs database table and the fuel information database table. This ability allowed the industry partners to review, update, and modify any inaccuracies that existed in these database tables due to changing conditions or to data input errors.

Cost Definition Files (CDF's)

The DPDST contained the ability to measure costs in a variety of ways using multiple criteria. This was accomplished in the prototype with the aid of cost definition files (CDF). A cost definition file is a file that contains information on what costs to include, exclude, or modify when calculating the cost dimension of the price. The use of a CDF is similar in practice to using a style sheet in today's modern word processors. For instance, one CDF may instruct the pro-

gram to measure shipment costs based on the price per mile of labor, but not to include capital costs in the same cost measurement, while another may include capital costs. The user can chose to use one or the other, and thereby avoid having to reset the options every time he/she wishes to calculate a price in a different way.

The prototype includes the ability to create and use as many CDF's as desired. For example, a CDF could be defined for team drivers, for specific market segments using a penetration strategy, for specific salespersons, or any other purpose desired. The cost of a shipment can then be measured repeatedly using distinct CDF's each time. This allows sensitivity analyses to be performed to determine the sensitivity of measured costs to certain costing definitions such as price per mile of labor or to certain cost categories such as capital costs.

The use of CDF's speeds up the process of measuring costs in a variety of ways. It also helps to insure that costs are measured consistently and correctly. The use of a CDF allows the user to have confidence that all cost measurements using the same CDF have been measured using the same set of costing criteria.

Cost measurements can be further customized beyond the use of a CDF by filtering the historical databases and using cost driver levels based upon restricted partitions of the historical data such as only the lowest measured events or only the shipments that occurred on Friday. Also, corporate rules-of-thumb can be used to override historical observations. This ability seems appropriate since historical data is being used to forecast future events. Management might be bidding on a new piece of business that would invalidate historical measurements. In this situation, management's best estimation of the cost driver levels of the new business should be used instead of forecasts using historical data.

Whenever the databases are updated, all CDF's are automatically updated. This requires that the prototype identify all CDF's in use. For this reason, all CDF's are kept in electronically identified locations so that they can be located and updated as new data is provided. This allows the prototype to show costs and prices of secondary geographic market segments using any CDF. Also, as multiple CDF's are used in sensitivity analyses, costs of serving secondary market segments are automatically updated to reflect the current CDF.

ITS Analysis in the DPDST Prototype

As mentioned in DPDST Development, it is important to identify the geographic market segments that are served prior to pick-up at the origin ("pre-shipment" market segments). Similarly, it is important to identify the geographic market segments that are served after delivering a shipment to the destination ("post-shipment" market segment). For completeness, it is important to know the cost associated with serving these pre- and post-shipment geographic market segments and the costs need to be displayed as an aid to establishing a price for the primary market segment being considered. In the DPDST prototype as now developed, there are no options for altering the measurements of the costs associated with these secondary geographic market segments. The cost measurements are calculated using a regression analysis of all historical data. For example, the optimal regression model would describe costs for secondary markets using a linear equation. The independent variables of this linear equation would consist of a subset of linehaul distance and time and non-revenue distance and time. The coefficients and variable selection process uses Akaike's model selection criteria. The analysis is accomplished by measuring the costs of each pre- and post-shipment geographic market segment and regressing these costs against their associated cost driver levels (these cost driver levels are

measured as the average value on a given geographic market segment). It should be noticed that the costs depend on the CDF being used. This requires that the regression be repeated for each CDF. The resulting model becomes a part of the CDF and is used in future cost calculations for secondary markets. The use of these regression models allows the multiple cost measurements to be calculated in real-time. The following example demonstrates how this regression analysis is accomplished.

Table 10 below gives an example of data that might come from the historical transaction databases. Initial reactions to the above might lead one to believe that the variable selection criteria from the information theoretic regression analysis should always choose the full model because of the way that costs are defined. However, not all components of costs are linear factors of the listed independent variables.

Fuel can account for more than 20% of calculated cost, yet it is not a simple linear function of the listed costs drivers since it is measured on a state by state basis. Similarly, fuel taxes are not a simple linear function of the listed cost driv-

TABLE 10

Historical Transaction Data on Pre-shipment Transactions

Cost	Linehaul Distance	Linehaul Time	Non-revenue Distance	Non-revenue Time
1.10	1457	34.00	53.25	9.93
1.86	452	16.29	92.81	33.45
1.48	1,043	54.88	160.71	22.91
1.72	323	8.49	73.08	17.57
1.63	965	82.98	48.00	5.32
1.82	1,037	73.37	103.80	31.87
1.45	697	19.03	85.59	29.36

ers for the same reason. Also, different market segments use distinct numbers of trailers causing non-linear relationships. Finally, some cost drivers might be insignificant in some CDFs (For example, CDFs can eliminate non-revenue activity from cost measurements, causing the cost drivers of non-revenue distance and time to be removed from all cost measurements).

The first question to address is one of variable selection. Which of the cost drivers should be included to yield optimal results? Using current data and the default CDF (created with the aid of an industry partner), linehaul distance is the dominant influencer of cost with linehaul time being a significant secondary influencer. Using Akaike's Information Criterion⁵ to identify the optimal variable selection, it is seen that for the particular CDF currently being considered, all cost drivers should be used to estimate measured costs of secondary geographic market segments. The prototype recalculates these regression analyses every time the historical databases are updated. The coefficients of the regression analysis are included in the CDF which allows for real-time cost estimates of secondary geographic market segments.

These analyses are done in the background so that the end-user does not even know that they are taking place. The ability to dynamically perform these calculations without user intervention is critical to the success of the DPDST and the prototype. To require users to make statistical choices in the model selection process would greatly limit the utility of the DPDST since many users would not be comfortable with the degree of required statistical expertise. Information theoretic statistics elegantly handles this situation by giving a criteria that yields an optimal model selection every time without user intervention.

5. Akaike, pp. 267-281.

Table 11 demonstrates how Akaike's model selection criterion arrives at a final multiple regression costing model for secondary market segments.

The lowest score listed in the second column of the above table is the best model and the one that is used by the software prototype. In this example, the full model is significantly better than any of the competing models and is used in the background to calculate costs of secondary geographic market segments.

It is interesting, also, to analyze the results of the regression analysis. The coefficients are listed in table 12.

TABLE 11

Multiple Regression Costing Model for Secondary Markets

Model	AIC Score
XOX1X2X3X4 ^a	-18.836
XOX1X2X3	44.929
XOX1X2X4	47.084
XOX1X3X4	79.190
XOX2X3X4	92.115
XOX3X4	52.207
XOX2X4	80.035
XOX2X3	91.024
XOX1X4	77.263
XOX1X3	92.905
XOX1X2	91.675
XOX4	78.742
XOX3	90.991
XOX2	95.285
XOX1	92.568
XO	93.696

- a) X0 — constant term
X1 — linehaul distance
X2 — linehaul time
X3 — non-revenue distance
X4 — non-revenue time

TABLE 12

Coefficients of Variables Used in Regression Analysis

Variable Name	Coefficient Value
Constant Term	.024168
Linehaul Distance	.581596
Linehaul Time	11.480300
Non-revenue Distance	0.580043
Non-revenue Time	11.472010

This shows that costs are about \$0.58 per mile and about \$11.47 per business hour when using this particular CDF. While this information is interesting for purposes of this discussion, it would be distracting in the setting of prices since this information does not directly influence the establishment of prices.

The use of AIC in performing the above analyses deserves some mention. AIC was the original criteria published by Akaike in his landmark article in the early seventies. Its value has been demonstrated for over two decades and its following has gained mainstream status. Other model selection criteria exist that offer advantages over AIC (such as Bozdogan's ICOMP⁶), however, AIC appears to perform adequately for the purposes of this study.

6. See for example: Bozdogan, Hamparsum, "ICOMP: A New Model Selection Criterion," *Classification and Related Methods of Data Analysis*, Hans H. Bock (editor), Amsterdam, North-Holland, April, 1988, pp. 599-608.

Bozdogan, "On Communications in Statistics..." 1990, pp. 221-278.

Bozdogan, Hamparsum, "Multisample Cluster Analysis of the Common Principle Model in k Groups Using an Entropic Statistical Complexity Criterion," invited paper at the *International Symposium on Theory and Practice of Classification*, Puschino, Soviet Union, December 16-19, 1990.

Bozdogan, Hamparsum, "Mixture-Model Cluster Analysis Using Model Selection Criteria and a New Informational Measure of Complexity," *Multivariate Statistical Modeling*, Vol. 2, Proceedings of the First US/Japan Conference on the Frontiers of Statistical Modeling: An Informational Approach, Hamparsum Bozdogan (editor), Kluwer Academic Publishers, Dordrecht, the Netherlands, 1994, pp. 69-113.

The DPDST was initially developed from about 28,000 historical records provided from the transaction databases of an industry partner, representing over 1,500 market segments. The time required to measure the cost for all individual market segments precludes this from being done. Instead, a sampling of market segments is used to calculate the optimal model. The use of sampling allows the calculations to be made in real time. This is important when new CDFs are created since a regression analysis must accompany this creation. Since CDFs, in the development of a price, are often used as they are created, the regression analyses must be completed in real-time. It is necessary that the CDF not take an undue amount of time to identify the optimal regression model or to calculate the associated regression coefficients. This forces the use of samples. Therefore, the regression analysis uses sampling techniques, basing its results on 50 randomly selected geographic market segments, allowing analysis to be accomplished in real time.

The elegance with which information theoretic statistics performed the above analyses cannot be overemphasized. Traditional statistics has no counterpart to reliably perform the optimal model selection without user intervention. The inclusion of this dimension of the DPDST in the prototype was considered necessary by the users in early versions, allowing users to consider and include necessary lane subsidizations and price balancing due to market pressures. An example of the process that leads to this type of pricing was discussed in an earlier example of a shipment from Olive Branch, MS to Phoenix, AZ.

Utilizing The DPDST Prototype

With all the options that are included, it can become difficult to keep track of which options are influencing current cost measurements or price suggestions. To combat this concern, much of the display is devoted to informing the

user of the underlying assumptions and criteria being used. Figure 30 is a screen capture of a price suggestion from the prototype software and demonstrates how this information is communicated. Notice that the screen informs the user that:

1. the "TEAM CDF" is being used.
2. 37 historical shipments from Olive Branch, MS 38654 to Phoenix, AZ 85000 were found using 5-digit zip code pairs.
3. 62 historical shipments were found that terminated at the destination of Phoenix, AZ 85000. The non-revenue miles that occurred after the delivery of these shipments was used to forecast non-revenue activity on this shipment.
4. The linehaul distance cost driver is based on average historical data.
5. The linehaul time cost driver is based on average historical data.

LandAir TruckLoad Costing Program

File Edit Transaction Tools Window Help

Costing Definition File in Use: E:\VBWIN\DISS\DISS4\TEAM.DEF

LandAir Transport, Inc.

37, 62 transactions used. (What If?) Origin: 38654, Destination: 85000

ORIGIN (ZIPCODE = 38654)	Olive Branch:	De Soto:	MS
DESTINATION (ZIPCODE = 85000)	Phoenix:	Maricopa:	AZ
Using 5 digit zipcode pair (origin to destination)	Using:	37 shipments:	from historical database
Using 5 digit zipcode from-revenue at destination	Using:	62 shipments:	from historical database
Revenue Miles (Calculations are based on)		historical data:	Average
Revenue Hours (Calculations are based on)		historical data:	Average
Non-Revenue Miles (Calculations are based on)		User declared value:	
Non-Revenue Hours (Calculations are based on)		historical data:	Lowest Quantile
Mileage:	1,469.96 Miles:	Revenue Generating:	Non-Revenue Generating:
Usage of Equipment (Labor & Capital time):	57.84 Hours:	1,457.00 Miles:	12.96 Miles
		51.35 Hours:	6.49 Hours
VARIABLE COST			
Labor:	\$514.49:	\$509.95:	\$4.54
Benefits:	\$176.40:	\$174.84:	\$1.56
Fuel:	\$229.60:	\$227.57:	\$2.02
Taxes/Fuel:	\$45.07:	\$44.67:	\$0.40

Average Low High What If? Declinations Historical Prices

Suggested Minimum Price: \$1,708.37 Low: \$1.32 per mile, Accessorial = \$0.00

Accessorial Charges: \$0.00 Average: \$1.32 per mile, Accessorial = \$0.79

High: \$1.40 per mile, Accessorial = \$14.57

FIGURE 30 Screen Capture of a Price Suggestion From the Prototype

- 6.** The non-revenue distance cost driver is based on a user input.
- 7.** The non-revenue time cost driver is based on the average value of the shipments from the lowest quantile of historical data.
- 8.** The lowest historical price on this geographic market segment is \$1.32 per mile.
- 9.** The average historical price on this geographic market segment is \$1.32 per mile.
- 10.** The highest historical price on this geographic market segment is \$1.40 per mile.
- 11.** The lowest, average and highest accessorial charges historically are displayed.
- 12.** The current measured cost and price suggestion includes no accessorial charges.
- 13.** The linehaul distance cost driver level being used is 1,457 miles.
- 14.** The linehaul time cost driver level being used is 51.35 hours.
- 15.** The non-revenue distance cost driver level being used is 12.96 miles.
- 16.** The non-revenue time cost driver level being used is 6.49 hours.
- 17.** The total (linehaul + non-revenue) distance cost driver level being used is 1,469.96 miles.
- 18.** The total (linehaul + non-revenue) time cost driver level being used is 57.84 hours.

The above information should provide the user with a degree of confidence that they understand the driving forces behind the cost measurements and the price suggestions offered by the prototype. It also should allow the user to progressively alter conditions in the pursuit of a reasonable price while keeping track of what conditions are currently being used.

Validation of the System

In practice, there were varied approaches to using the prototype. For example, some end-users seemed to assign prices based upon cost measurements that used the lowest historical observations with the reasoning that these measurements represented the company's operations when nothing went wrong. It was pointed out that this would always lead to a price below average measured cost and that if all prices were set below average cost, corporate profitability goals would not be met. While this concern was understood, the solution was relegated to the operations domain. Others took more time to perform deeper what if analyses.

Economic Impact of the DPDST

The economic impact of the DPDST on the industry partners of the system will be reported in phases. As planned, this impact was measured through the administration of a written interview or survey (discussed in part III). The written interviews were completed by three individuals occupying varying levels of responsibility—the time demanded by the written survey precluded greater participation. The economic impact was measured further through investigative research using the DPDST prototype itself, and through in-depth interviews with personnel at various levels of responsibility among the industry partners. The first phase will report the direct, immediate economic impact that the DPDST had on the industry partners. The second phase will discuss some of the investi-

gative reports completed with the aid of the prototype that illustrate influences that the prototype could have on the industry partners. Finally, a third phase will report on the anticipated future economic impact of the DPDST.

Phase One—Reported Direct Impact of the DPDST

The prototype of the DPDST was implemented in stages as computer code revisions occurred. This precluded a stable form of the prototype from being used for long periods of time. The process of developing the prototype spanned over a year with multiple meetings with mid- and upper-level management. These meetings ranged in duration from a few minutes to all day. Multiple users and contributors participated in these meetings. For example, cost analysts, pricing analysts, and MIS department heads spent considerable time examining and working with the prototype, as well as working out problems or difficulties with providing data or with improving the user-friendliness of the software.

Due to the frequent updates in the computer software prototype, some of the planned research questions were limited in scope and depth. Another limiting factor was the inability of the industry partners to carry out some planned analyses "by hand," that is, without the assistance of the prototype.

This problem was particularly evident in responses to the first three written interview questions. Question two, in particular, which asked for the industry partners to list their costs associated with serving 25 geographic market segments, created some difficulty. In spite of the limited participation level on this exercise (only three persons completed the written interviews or surveys), this reporting of measured costs without the aid of the DPDST was deemed so time consuming and difficult that participants declined to answer this question. They estimated that this cost measurement activity would have taken several weeks of full-time effort to complete.

It is believed that the inability of industry partners to calculate their costs is an even stronger statement than was originally hoped for. The prototype was able to accurately measure costs, and this was in contrast to a complete inability prior to the implementation of the DPDST prototype.

The research showed that the DPDST prototype did have an impact on the industry partners. In addition to the new ability to measure costs, the written interviews listed several immediate impacts of the prototype, including:

1. removing conflicts in P&L measurements;
2. removing conflicts in lane analyses;
3. cost analysis; and
4. analysis of unit business.

Lane analysis was another area where the influence of the prototype was clearly seen. As previously mentioned, the industry partners found accurate and detailed cost measurements for operations or pricing purposes to be so time consuming that the activity received only occasional and specialized attention before the implementation of the DPDST prototype. However, this activity became possible through the use of the prototype, and industry partners performed analyses that revealed concerns or problems on several of the lanes in question that were previously unknown. The process of using the prototype also gave insights into the profitability of the given lanes that differed from perceptions before using the DPDST.

In the analysis section of the written interview, participants were asked to analyze 25 specified lanes using the DPDST. This was completed twice, once without the aid of the prototype and once with. The participant took advantage of all tools at his/her disposal just as would be done in an actual day-to-day setting. The activity was completed again at a later time using the DPDST. That is, the same persons answered the same set of lane analysis questions again, but

the second time the participant answered the lane analysis questions, he/she was free to use all tools at his/her disposal, including the DPDST prototype.

The two experiences differed significantly in several respects. Some of the primary differences included the ultimate conclusions regarding lane profitability, and the time to complete the activity. Of the 25 lanes analyzed, 16 were considered profitable without the aid of the DPDST. After the DPDST was implemented, only 8 were considered profitable.

The time required to complete the lane analysis portion of the written interview took 45 minutes without the aid of the DPDST. However, the same analyses took considerably longer than two hours when using the prototype due to an abundance of "what-if" options and a lack of user-friendliness.

The participants were unable to give an exact measure of the time that the second response to the activity demanded due to the length of its time demanded and conflicting commitments that precluded their completing the second response in "one sitting."

An interesting response to the final written interview showed that uniformly, all respondents felt, without the help of the DPDST, that prices fell below totally allocated costs not quite half the time (all three responses were two on a Likert scale from zero to five inclusive). However, when the participants utilized the DPDST to evaluate 25 market segments, responses suggested that prices fell below totally allocated costs nearly two-thirds of the time.

Phase Two—Results of Investigative Reports on the Impact of the DPDST

In an effort to further investigate the apparent overabundance of unprofitable geographic market segments, analyses were performed by randomly selecting market segments from the provided databases and analyzing them via the

DPDST prototype. One analysis, covering only ten geographic market segments, showed prices fell below totally allocated costs 80% of the time. On examination, this was found to be due in part to the inclusion of capital costs. When capital cost requirements were changed from the 12% per year (suggested by management to be their goal) to 6% per year, the number went from 80% down to 60% of all shipments that did not cover totally allocated costs. This suggests that the business unit of the industry partner involved in this study may not currently generate a return on investment of 12%, but rather may be closer to generating returns in the 5% or 6% range.

To further investigate this, a second analysis was performed on a larger random sample. In this analysis, 40 geographic market segments were selected and were found to contribute precisely 6% towards capital costs (dividends and retained equity).

Again, as in the former and smaller analysis, 60% of the market segments did not cover totally allocated costs. However, total costs and total revenues did balance over all 1,957 transactions involved, and all costs were covered (including dividends and equity with a 6% annual return). This was made possible by the fact that the geographic market segments that covered costs (representing 40% of the sampled market segments) were high-traffic lanes, encompassing 66.5% of all shipments, and 71% of all revenue miles.

It should be mentioned that the level of 12% return on capital costs was considered appropriate by management in multiple conversations. The mention of 6% return on capital costs is included because this figure appears to be the amount that the business unit of an industry partner that participated in the project is actually achieving at present.

In conversations regarding these issues of inadequate return, management did not seem to be disturbed. The responses ranged from 1) a distrust of the precision of the DPDST or the data that had been fed into the prototype to 2) a belief that the current economy does not allow greater profitability in TLMC industry. However, further conversations revealed that upper-level management was aware that current profits were only covering about half of the capital cost burden. This coincided with the measured result.

During the multiple conversations, interviews, and experiences with industry partners, it became apparent that market conditions do not permit prices to follow costs on every geographic market segment. Instead, pairs or triangles of geographic market segments need to be considered simultaneously with one leg of the circuit subsidizing the other(s). The aim becomes to make the average of the two or three shipments profitable.

This understanding of the dynamics of the marketplace may explain the belief expressed by management and by pricing personnel that about 50% of all shipments do not cover totally allocated costs. In spite of this attempt by industry partners to average their profits across multiple shipments, they did not seem to be aware of the specific profitability levels suggested in the preceding paragraph.

An interesting side note was the noticeable distinction between upper-level management and mid-level managers. Upper-level management seemed to be aware of the significance of contributions towards capital costs and seemed to be inclined to find solutions to the apparent problem. However, mid-level management seemed appeased by the statement that "this is the real world."

One costing analyst made the statement that in the current market, they just tried to keep their equipment moving and make sure that they covered their

fixed costs. He repeatedly emphasized this, making clear that he had no concern whatsoever about covering variable costs. He appeared to feel that as long as the commitments the company had made, such as for tractors, were met, then a better day would arrive in the near future.

He never made mention of any concern to cover variable costs! It is not clear if this is due to a complete lack of understanding of basic economics or if the cost analyst was expressing a need to cover both variable (unmentioned) and fixed costs, with no contribution towards capital costs.

Through many hours of in-depth interviews, it became apparent that a factor that severely limited the utility of the DPDST in practice was the lack of understanding by practitioners of the multiple dimensions of price. Further, upper-level management seemed to lack commitment to achieve a high level of expertise in the pricing function. Conversations with vice presidents showed that positions that established prices, frequently, were staffed by persons with limited skills and abilities. The persons that established prices might lack fundamental grounding in all dimensions of price. The final point of concern was the lack of an ongoing training or education program for pricing personnel.

Phase Three—Reported Anticipated Future Impact of the DPDST

As discussed in the previous sub-section, the prototype did play a limited role in economic decision making and revealed economic facts regarding operations and pricing practices that were not known or understood by the industry partners before implementing the DPDST. However, time, as well as a general lack of user-friendliness on a few key points precluded the tool from achieving the industry partner's vision of its full potential.

On the questions of the written interview asking for impressions of whether or not the tool should be continuously developed and how much the company should be willing to pay for the tool, unanimously, everyone felt that the DPDST prototype should continue to be developed. Mid-level management suggested that a investment to continue to develop the prototype might range from \$5,000 to \$10,000. Upper-level management was uniformly unable or unwilling to give a dollar value for the further development of the prototype but did express desires to see it further developed.

The fact that all levels of management expressed the desire to see the DPDST prototype further developed was considered a positive sign, further indicating the potential of the prototype. Several specific suggestions for improvement and/or further development were made by various personnel, many of which appear to have significant potential. These will be discussed in part V, "Conclusions and Future Directions".

Many of the advantages of the prototype went beyond the measurable labor savings, the increased profits, or the increased knowledge of system profitability. Many of the advantages of the tool appeared to be a perceived value due to several causes such as an increased comfort level with pricing or operation practices. This will be discussed in the next sub-section.

Perceived Value of the DPDST

The perceived value of the DPDST was measured with the aid of the written interviews or survey instrument and with the aid of multiple in-depth interviews with industry experts and industry partners. Without exception, all comments were to the positive, in that all expressed, in one form or another, the opinion

that the industry needed a tool such as the herein developed DPDST to aid decision making.

The written interview responses emphasize this point. The responses to question four on the written interview, "How useful do you feel the pricing suggestion system (DPDST) is?" averaged 4.5 on a Likert scale from zero to five with zero being not useful and five being very useful. Question six of the written interview explained the response to question four to some extent. Question six asked "How often was the DPDST used by: upper-level management, marketing personnel, and front-line personnel."

The responses varied by managerial level. Upper-level management felt that they used the tool at least monthly while mid-level managers felt that upper-level management seldom used the tool.

Regarding marketing's use of the tool, again upper-level management differed from mid-level managers in their responses. Upper-level management responded that marketing personnel would use the DPDST daily while mid-level management reported that marketing personnel would use the tool weekly.

This difference was due in part to how participants interpreted the question. It became clear from in-depth interviews that many of the responses to the written interview were based upon expectations of future use of the tool after it was incorporated into normal activities. Therefore, the differences in the responses suggests differences in perceptions regarding future use of the tool. However, in both cases, it was perceived that the tool would be used frequently by marketing personnel and less frequently by upper-level management. No one interviewed felt that front-line personnel would ever use a tool of this nature.

Question five, "What do you believe to be the principle uses of the DPDST?" yielded several responses. The primary responses coincided with comments in in-depth interviews. The uses, both experienced and anticipated were:

1. cost analysis,
2. profit and loss analysis,
3. system impact of potential new business, and
4. individual account profitability analysis.

This implies that the ability of the DPDST to suggest prices by measuring several different dimensions of price is perceived to be of greatest use in auxiliary and supporting functions to price establishment rather than directly establishing prices.

However, this observation should be moderated since everyone enthusiastically expressed a desire to use the prototype in completing bids for new business. This should allow the expansion of the utility of the DPDST and will be discussed in some detail in part V of this dissertation.

Question seven asked the influence of the DPDST on brokering. No one felt that the DPDST would influence brokering in any way, directly or indirectly. This was surprising to the author since it was anticipated that brokers or owner operators might be employed at an increased frequency if costs greatly exceeded price due to excessive non-revenue activity. It was suspected that these costs could be transferred to third parties, increasing system efficiencies. This suspicion proved to be unfounded both in written and in-depth interviews.

Question eight addressed the role of the DPDST on contract or dedicated business. All respondents reported that the DPDST had no influence. However, in-depth interviews universally revealed that they expected it to be used in future negotiations. The discrepancy appears to be due to timing and the lack of ongoing negotiations during the placement of the prototype. Also, some partici-

pants expressed the wish that the tool had been available a few weeks earlier during a particularly long and involved contract negotiation. If this had been the case, the response to this question may have been somewhat different.

Question nine dealt with the role of the DPDST in negotiations of total logistics services. It was reported that the tool would be used to analyze unit business and was used to assist in developing costs. It was felt that the tool held great potential in this area.

Question ten dealt with any conflicts that occurred in implementing the system. Time and training were the most often mentioned complaints. Problems with data conversion also was mentioned. There is little doubt that this last complaint was mentioned because of the great effort that was required on the part of the industry partners to provide the exhaustive transaction data (in a variety of formats and on multiple occasions). This heroic effort on their part was and continues to be greatly appreciated by the author. It is anticipated that much of the data transfer and manipulation will be automated in the future, resolving much of the difficulty mentioned. This data automation will be further discussed in part V.

Question eleven dealt with any conflicts that the tool helped resolve. The responses ranged from profit and loss lane analysis to "reality versus 'gut'." These responses have been mentioned previously in the general discussion of benefits of the prototype.

Question twelve asked if the DPDST might influence corporate policy on such items as allocation of overhead or shared costs. Both in-depth and written interviews reported no. However, one participant did respond that, although the DPDST did not have any influence at present, perhaps in the future it could influence such corporate policy.

When asked, in question thirteen, if the DPDST would drive down variability (variation in prices, profits, etc.), responses were in the affirmative. This, again, will be an area that will be investigated more thoroughly in future research.

The respondents varied in their responses to question fourteen of the written interview. The question asked for the attributes or features of the DPDST that provided the greatest benefit. The responses were:

1. "sanity check" in pricing
2. zip to zip pricing
3. ability to use a large amount of historical data
4. ability to see impact of time on total cost
5. histogram feature helps in identifying bad data

The second response, zip to zip pricing, was due to the ability of the prototype to measure costs and suggest prices on 5-digit zip code pairs. Currently, the industry partners are not able to measure costs on such a precise basis. Their current ability might include a "freight pocket" as an origin or destination that could have a diameter of over 100 miles.

This would give the potential of being off as much as 200 miles or more in some geographic market segments for cost calculation purposes or for non-revenue information. The ability to focus the historical data more precisely seemed valuable, particularly in some situations.

The fourth response was important since currently, many corporations base costs completely on a per mile basis. Others base fixed costs on a time basis while measuring variable costs on a per mile basis. In these situations, time is not captured precisely on the non-revenue side. It is common to average all non-revenue costs evenly across all shipments by assigning all shipments a corporate average for all non-revenue miles and non-revenue time. The ability of

the DPDST to extract from the data precise measurements of non-revenue activity on geographic market segment bases was considered valuable.

The fifth response addressed the identification of bad data. Some geographic market segments allow tractors to sit idle for a day or more at a company terminal while the driver rests. The equipment is considered to be out-of-service during these times. However, the historical data does not flag these activities.

Users of the prototype needed to identify when measured costs and suggested prices were driven by such occurrences. The histograms reveal these data problems by showing a large percentage of shipments in some geographic market segments that recorded linehaul times as much as 24 or 48 hours longer than would be expected. When this occurred, the industry partners did not base measured costs and suggested prices on averages for the particular geographic market segment.

Question fifteen dealt with the features of the prototype that created the greatest aggravation or concern while being used. There were two categories of responses to this question, 1) a lack of reporting features and 2) a lack of user friendliness. Discussion about reporting features will be included in part V. An example of the lack of user friendliness included the manner in which the prototype forced the user to choose between 3- and 5-digit zip codes when viewing the historical transaction database table. Another was the way that the prices can either be based upon historical data, averages, or market pressures. It would seem that the latter concern should exist with or without the DPDST. However, this is not always the case. Therefore, when the DPDST forced the users to compare and harmonize the many different dimensions of price, some found this new wealth of information overwhelming and too time consuming for their liking.

Question sixteen asked how open in negotiations the industry partners would be with the information provided by the tool. The answers ranged from 1) not open, to 2) some, to 3) very open. This responses to this question seemed to vary more than any other question. Continued use of the prototype will be needed to clarify the role it will actually take in negotiations.

Question seventeen asked how the respondents expected the tool to help in the establishment of customer service levels. The respondents felt that the tool could help identify the "best" or most profitable customers. This would allow management to adjust service levels from customer to customer or from geographic market segment to geographic market segment depending upon profitability or costs.

Question eighteen asked how the tool might influence customers. Respondents felt that the tool would not influence customers unless there was an economic shift in the market resulting in a "sellers market." Again, if further use of the DPDST prototype shows that it is used a great deal in negotiations, this response could conceivably change, but is a question that will have to be left for future research.

Responses to question nineteen proved to be interesting. It asked if company prices follow measured costs. Mid-level managers who spent the most time with the tool responded that they did not while upper-level management felt that prices did follow measured costs.

In spite of this discrepancy, in-depth interviews showed that upper-level management understands that some geographic market segments do not cover totally allocated costs and are subsidized by more profitable geographic market segments that receive excessive profits. For example, as mentioned previously, an industry partner charged \$1.33/mile from Olive Branch, MS to Phoenix, AZ

which was \$0.11/mile in excess of fully allocated costs. However, it usually lost money returning to an eastern city such as Atlanta, GA. Management hopes that, on balance, the two shipments are profitable. All respondents expressed this same view during in-depth interviews, in spite of the differing responses to the written interview. This may show that upper-level management views the question from a system perspective while mid-level managers view the question from a shipment by shipment perspective.

Questions twenty through twenty two were discussed in the earlier subsection on economic value (see page 196). However, these questions also deserve passing mention here since they deal with how the users perceived the tool. Everyone involved with the project felt that the DPDST was valuable and that the tool should continue to be developed.

Summary

The development of the DPDST proceeded as was proposed in part III. It incorporated all of the aspects of pricing explored and discussed in the earlier parts of this work. Software development of a prototype of the system was accomplished in stages, as discussed, and was successful in incorporating nearly all aspects of the DPDST.

Once a usable prototype was available, the software was placed on-site with industry partners, and validation procedures were implemented. Validation efforts had to be somewhat curtailed in breadth because of the time-commitments involved in the validation process on the part of the industry personnel who evaluated the prototype. The time investment and the significant cooperation of the many personnel involved were greatly appreciated by the author

In spite of the imposed limitations, the validation outcomes were positive. They show that the DPDST, both in general as a theoretically-based pricing system and in its software form, can have a positive impact on industry, and should be further developed and improved.

Part V

Conclusions and Future
Directions

Introduction

This part of the research will consist of four sections; 1) Introduction, 2) Conclusions of this research, 3) Plans for continued research, and 4) Summary. The research has explained the need for a dynamic pricing system in part I and established a theoretical foundation upon which to build the dynamic pricing suggestion system in part II. The research objectives were designed to develop a Dynamic Pricing Decision-Support Tool (DPDST) that would include all theoretical dimensions of price and to automate the DPDST with a software prototype that could be used and tested by industry partners. The research objectives then proposed that the research validate the value of the pricing system in industry through measurements of the industry partners' experience.

All objectives were met and the DPDST was found to be a valuable tool that does not currently have a counterpart in the TLMC industry. The general value of the tool to industry was illustrated primarily by the reactions of multiple industry experts and practitioners from many distinct backgrounds that uniformly expressed positive reactions to the software prototype. Specific, detailed validation of the DPDST was the weakest part of the research due to the limited number of industry partners participating in this specific part of the study. Generalization of the validation results of the study to the industry as a whole is reasonable but statistically unproven.

Future research will concentrate on improving and enhancing the statistical quality of the validation of the DPDST in industry. Efforts will be concen-

trated on further evaluation of the value or worth of the DPDST both to the industry partners who participated, as well as to a wide variety of TLMC's.

In addition, improvements will be made to the software prototype. Some suggestions for these improvements have already been made by industry partners, others will be mentioned in the following. These improvements will cover both efforts to fully incorporate all the theoretical aspects of the DPDST as discussed in part IV, as well as efforts to enhance its "user-friendliness," and therefore utility to a wide range of TLMC's, as directed by user feedback.

Conclusions

This research led to the following conclusions:

1. A DPDST Can be Developed that Incorporates all Dimensions of Price and it Can be Automated

By utilizing all dimensions of price touched on in parts I and II, and further elucidated in part III, it was found that a fully functional Dynamic Decision-Support Tool could, in fact, be developed. This development was accomplished, as discussed in part IV. As further proposed earlier in the dissertation, the DPDST was, in fact, operationalized in the form of a software prototype. The process of developing both the DPDST and its prototype required many "stutter steps", with frequent feedback from industry partners. However, the goal eventually was accomplished, and the prototype was placed on site with industry partners for the validation phase.

2. Partial Implementations of the DPDST (Lower Dimensional Pricing Systems) Proved to be of Marginal Utility

One of the more illuminating "stutter steps" encountered during the development of the software prototype was an attempt to operationalize the system with only selected dimensions of price incorporated. Although this was done at the specific request of industry partners (who felt that management had a sufficient "feel" for the other aspects of pricing that incorporation of these "other" dimensions was unnecessary), both the end-users of the prototype, as well as the author, found that this "non-professional version" was simply inadequate.

Industry partners generally found this early version to be interesting, but of limited value. However, once all dimensions of price were incorporated either directly or indirectly into the software prototype, the prototype was found to be very useful.

3. The Software Version of the DPDST Allows Greater In-depth Analyses in Price Establishment

The DPDST allows decision makers to consider a variety of information while establishing prices. This plenitude of information should be contrasted with the current status quo. Several industry partners shared that it is common to establish prices by guess-work alone. The analyses that would seem natural and necessary in setting a price are so time consuming that they are rarely done. The DPDST allows decision makers to dynamically perform sensitivity analyses to measure how sensitive profits or costs are to operational or pricing changes. It also allows the consideration of operational and system characteristics such as lane imbalances or profit balancing among multiple shipments. The wealth of information now available should promote better and more profitable decisions and increased confidence in the decision-making process.

4. Management Needs Training to Take Full Advantage of the DPDST

A surprising point that came to light during the work with the industry partners, was the inability of many users to take full advantage of the power of the prototype. It quickly became clear that this inability stemmed from the fact that they were not accustomed to consider all aspects or dimensions of price before making an offer.

Furthermore, users of the prototype often manifested a lack of understanding of some fundamental principles regarding the establishment of prices. Of

greatest concern was the lack of understanding demonstrated among mid-level managers, since they often make the small day to day decisions that cumulatively determine the profitability of the company.

It became clear that users of the DPDST prototype, in order to take full advantage of the pricing system, generally need to be trained in the theoretical background of the system to establish an understanding of the fundamental principles regarding pricing. They would then better be able to incorporate all dimensions of price into the decision-making process.

Once the users were well grounded in the theoretical foundation, they would benefit further from training in use of the software tool. The translation of theory to the "real world" often needs assistance or training. The implementation of the DPDST is no exception in this regard. Training on how to take full advantage of the tool should yield large dividends.

5. Research Suggests that the DPDST will be Welcomed by Industry

Throughout the experience of developing the DPDST, the many participants in the research have universally been supportive and positive. These have included both industry partners directly involved with the development of the DPDST, as well as other experts in the field, both in education and in industry. None have suggested that the abilities provided by the DPDST were unnecessary, unneeded, or even already available. Rather, all have responded that the ability should greatly enhance the pricing decision-making process. Those who have examined and commented on the system have ranged from presidents and board members of TLMC firms to academicians. Some even admitted that they had unsuccessfully attempted to build a similar system. All evidence suggests that the DPDST should be welcomed by the industry.

6. The Availability of the Information Provided by the DPDST Closed the Distance Among the Functional Silos of Pricing, Marketing, and Operations

Another unexpected finding from the on-site experience with industry partners was the dynamic interplay it induced among the functional silos of pricing, marketing, and operations. This became more common the longer the prototype was used by industry partners. Comments such as "that is a marketing problem," or "that is an operations problem" became increasingly frequent. These were not antagonistic comments nor excuses, but rather led to discussion and interaction with the appropriate personnel. In fact, generally all persons involved seemed to be in agreement as to how a problem should be solved. The DPDST seemed to provide a means of communicating necessary information to move problem solving from the finger pointing stage to the cooperative problem resolution stage.

7. The Incorporation of the DPDST Will Give Firms a Competitive Advantage

The economic section of the written interview revealed that management's understanding of market segment profitability was enhanced while using of the DPDST. Further, the DPDST exposed operational characteristics of the industry partner's systems that had been hidden before implementing the DPDST, and thereby increased understanding by management. For example, information regarding lanes that feed into or out of a geographic market segment was not readily available before implementation of the DPDST. Therefore, information regarding lane imbalances was better understood through the use of the DPDST.

Finally, costs could not be calculated precisely on a lane-by-lane basis prior to implementing the DPDST. Through the use of the DPDST, the industry partners were able to do these calculations. This ability allowed the industry partner

to incorporate greater efficiencies into the system and to improve pricing practices. Both of these benefits provided by the DPDST should translate into competitive advantage.

Future Directions

Future research plans fall into three categories, 1) improving the statistical validation of the value of the DPDST, 2) increasing the depth of the current research and 3) expanding the breadth of the current research. The following sub-sections will discuss these two research thrusts.

Improving the Statistical Validation of the Value of the DPDST

As mentioned previously, the part of the research that left the most to be desired was the statistical validation, particularly of the perceived value of the DPDST prototype. Much of the difficulty had to do with the intensive time commitment required to give full and accurate responses to the written interview. It is hoped that as improvements are made to the prototype, particularly to improvements in functionality, time required for evaluation of the prototype will be significantly reduced. Further, familiarity with the programmed prototype should increase, further reducing evaluation time.

As evaluation time is decreased, further, more in depth evaluation of the impact of the system and its prototype will be made possible. To further broaden the evaluation of the DPDST, it is hoped that many other participants, from a wide range of TLMC companies will become involved. The most significant validation of the system would be if it proves to be of value to multiple companies and

operating systems. This process of extensive validation is expected to be an ongoing effort.

Increasing the Depth of the Current Research

One of the most frequently mentioned issues brought up by upper-level management was the lack of reporting features in the software prototype. This was felt to be its greatest shortcoming. For example, management wanted to be able to print reports on lane imbalances and system profitability. They also wanted to see the impact of new business on the existing system. This last point is subtle since a new shipment might be unprofitable, but still improve system profitability because of lane balance issues or because it might be less unprofitable than other transactions that it might replace.

Mid-level managers (the personnel that used the software the greatest amount) felt that user-friendly features were the greatest concern. Currently, users feel that the interface is too time-consuming to use. The area of greatest frustration came from the manner in which the prototype forced the user to input the origin and destination identification. This interface should be refined in conjunction with end-users to optimize its usability.

Other areas that require greater development in the software are computer programming related. For example, a written users' manual and on-line help are items that users requested. Also, programming "bugs" exist in the program. If a user is not careful, it is possible to input inappropriate data into some areas of the program as it currently exists, and the data will be accepted and used in unpredictable manners. Also, the programmed prototype occasionally experiences "crashes". This is infrequent enough that such occurrences did not

adversely influence the current research, but it does offer an opportunity for improvement. Finally, the speed of the prototype should be improved in a few aspects. This will allow the scope of the program to be increased. This will be discussed in the next sub-section.

Expanding the Breadth of the Current Research

Placing the software prototype on-site with industry partners has allowed the limitations of the DPDST to be starkly manifested. Typically, any limitation comes from the restricted scope of the system and tool. For example, management of the industry partners has expressed a desire to incorporate into the prototype the ability to suggest prices for electronic lists of geographic market segments for purposes of bidding.

In fact, everyone enthusiastically expressed a desire to use the prototype in completing bids for new business. These bids, at present, often take more than four days of full-time effort to complete. If the price suggestions could be "batched" so that they could all be done without user intervention, the DPDST could be used to complete the bid proposals. This would probably become one of its primary uses. The ability to "batch" these suggestions is an ability that was not anticipated but should be easy to implement. This should allow the expansion of the utility of the DPDST.

As the research unfolded, the recurring theme that marketing, pricing and operations need to work in concert, harmonizing all activities of the company kept surfacing. Therefore, it became common to hear the industry partners say that a historical price was unprofitable but that the solution to the unprofitability was a marketing or operations responsibility rather than a pricing problem.

Because of this interplay, many of the requested additional features to the software prototype were operational in nature. For example, management expressed a desire to identify "freight pockets." They wanted to be able to automatically locate geographic areas that have high activity levels. They will then use this information to focus marketing efforts.

One of the principal bottlenecks in the implementation of the prototype was the tremendous effort needed to update the data. This will be automated in the near future, allowing the industry partners to update their data as often as they desire.

This effort has been facilitated recently with improvements and expansions of the information systems used by TLMC's. For example, the industry partners now collect fuel tax rate information and will soon be able to update the fuel database as often as desired. Previously, this information had to be entered by hand.

Another technology that has recently been developed that furthers these efforts is the improvement of ODBC links that simplify the connecting of PC based programs with databases on separate computers and computer systems such as an IBM AS/400. The downloading and updating of the data can now be initiated and controlled from the PC. In fact, the automation of this feature can be as simple as inserting the command to update the data files as a menu option in the software prototype.

When asked, in question thirteen, if the DPDST would drive down variability (variability in prices, profits, etc.), responses were in the affirmative. This, again, will be an area that will be investigated more thoroughly in future research.

Summary

The need for a Dynamic Pricing Suggestion System became clear as the importance of pricing in general, and specifically as it relates to the truckload motor carrier industry was explored in part I and part II of this dissertation. Research questions were proposed in part III that focused the direction of development of the DPDST as a tool.

These questions also explored the need for a usable prototype of the DPDST in order to confirm the value of the system to industry. It quickly became obvious that a usable prototype of the DPDST would need the power of modern-day computers to reach its full utility. A software prototype of the system was therefore proposed. The last six research questions involved validation of the usefulness and worth, both economic and otherwise, to the TLMC industry.

Although some partial answers to the research questions were illuminated through the literature review presented in part II, answers to the research question were completed in part IV. The full DPDST was developed, incorporating all the diverse aspects of pricing. Part IV also presented the development of the operational software prototype and its placement on-site with industry partners. A measurement of the value of the DPDST to industry was obtained 1) through the evaluation of the reaction of industry partners to the prototype, and 2) through measurement of the economic impact of the prototype on the industry partners' operation. The evaluation of the reactions of industry partners to

the prototype were obtained both through written and in-depth interviews with upper- and mid-level managers.

The perceived value of the DPDST was highly favorable among all users, although problems, mostly involving usability of the software prototype itself, rather than with the DPDST as a theoretical system, were expressed by some respondents. There was general consensus among responses to the written interview that the DPDST and its software prototype merits investment in future development and refinement of the software by industry partners. In a sense, this comment, in and of itself, is a strong indicator of the value of the DPDST system.

The economic value of the DPDST came from its ability to refine management's understanding of their own pricing system. For example, the DPDST did change management's belief regarding system costs and profitability. It is difficult to put a numeric value on the economic impact of the DPDST, but mid-level managers suggested that \$5,000 to \$10,000 should be invested in the future development of the prototype. The potential economic impact of the DPDST to annual profitability appeared to be much greater than this number.

Although the DPDST as a system appeared to be theoretically sound, the software prototype that was developed was not a perfect piece of software. Future research will continue the validation of both the theoretical system and of the software. The scope of the validation will be expanded to better represent the TLMC industry as a whole. The software prototype will continue to be developed and refined, guided both by improvements in the DPDST as well as by suggestions from end-users of the programmed prototype. It is hoped that this DPDST, both as a theoretical system and as a software tool, will prove to be a

valuable aid in management of the TLMC industry, and perhaps in other industries as well.

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Vita

Gregory M. Kellar was born in Mobile, Alabama on October 16, 1956. He attended elementary and high school in the public system of Mobile, Alabama, where he graduated from Davidson High School in June 1975. He entered Brigham Young University, Provo, Utah in September, 1975, where he received the Bachelor of Science in Mathematics in August, 1981. He entered the Master's program in Mathematics at Brigham Young University in August, 1981, receiving the Master of Science degree in August, 1983. He entered the Ph.D. program in Mathematics at The University of Tennessee, Knoxville in September, 1983. He studied in this program continuously until May, 1989. He then transferred into the Ph.D. program in Logistics and Transportation at The University of Tennessee, Knoxville in June, 1989. He received the Masters of Business Administration degree in May, 1995. The doctoral degree in Business Administration was received August, 1996.

While earning his doctoral degree, he was privileged to participate in several research projects, academic conference presentations, and publishing opportunities. He has presented papers at the annual meetings of The Transportation Research Foundation, Delta Nu Alpha, and The Council of Logistics Management. In addition to publishing papers in the proceedings of the previously mentioned conferences, he has published in *The Transportation Journal*, *The Journal of Business Logistics*, *The Journal of Transportation Law, Logistics and Policy*, and *The Journal of Transportation Management*. Also, he was awarded the Plow-

man award for best paper of the year at the educator's session of the annual meetings held by The Council of Logistics Management in October, 1993.

Soon after his acceptance into the Ph.D. program in Logistics and Transportation, he was also accepted into the Master's program in Statistics at the University of Tennessee, Knoxville, and continues his studies in this area.