To the Graduate Council:

I am submitting herewith a dissertation written by Thomas H. Lederer entitled "Analysis of Cost and Supply for Fire Protection Services in the Smaller Municipalities and Rural Areas of Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

M. B. Badenhop, Major Professor

We have read this dissertation
and recommend its acceptance:

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ANALYSIS OF COST AND SUPPLY FOR FIRE PROTECTION SERVICES IN THE SMALLER MUNICIPALITIES AND RURAL AREAS OF TENNESSEE

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee

Thomas H. Lederer

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ABSTRACT

Fire protection is a public service that plays a unique role protecting human life and property in a community. Recent studies indicate that fire protection is one of the key community characteristics in the plant location and expansion decisions made by industrial leaders, yet fire protection services are recognized to be severely inadequate in the rural areas of Tennessee. For these reasons, the specific public service to be analyzed in this study is fire protection.

The problem faced by local government officials is to maintain and/or increase the quantity and quality of local public services in the face of a generally unfavorable financial situation. This issue, as it relates to the delivery of fire protection services, will be the focal point of the theoretical and policy considerations found in the study.

The overall purpose of this study is to gain a fuller understanding of the economic costs of supplying fire protection services to the smaller communities and rural areas of Tennessee. The specific objectives are:

1) To examine topics of importance to the economic analysis of fire protection and to discuss the theoretical viewpoints relevant to the economic analysis of the cost and supply of a public service.

2) To specify and analyze models of the total and average cost of supplying fire protection services.

   a. To incorporate within the cost models a measure of quality and an imputed value for voluntary effort.

   b. To determine the existence and magnitude of economies or diseconomies of size associated with the cost of supplying fire protection services.

3) To delineate a supply function for fire protection services.

An economic model of the cost of supplying fire protection services is presented that incorporates an imputed value for voluntary effort. The basic concern is with those variables that are hypothesized to be determinants of cost. A total cost model is specified with consideration given to the measurement of quantity and quality of output, and the definition of the environment in which this public service is delivered.

The basic economic model of total cost and two modifications of the model were analyzed by using multiple regression techniques. Data requirements necessary for the analysis were fulfilled from a combination of primary and secondary data sources. Secondary data were supplemented by primary data obtained from a comprehensive survey of fire chiefs in Tennessee. Each estimation is discussed in terms of the explanatory power of the model and the level of significance, behavior, and magnitude of the results displayed by the variables considered.

The major conclusions from the study are as follows: 1) The evaluation system for fire departments needs to incorporate within it indicators of individual quality performance such as actual response time, fire suppression effectiveness, and specialized rural equipment. 2) The total cost of supplying fire protection services is more dependent upon the quantity and quality of output supplied, the number of alarms related to fire protection, and the number of professional firemen than the physical environment in which the service is delivered. 3) The average cost function was hypothesized and shown to be L-shaped indicating

the presence of economies of scale for the delivery of fire protection service beginning very gradually at a population protected level of 2,000. A stable low point nearly parallel to the quantity of output axis is reached beginning at a population protected level of around 12,000. 4) General revenue sharing is assumed to decrease the risk and uncertainty for local decision makers in terms of finances for public purposes and politics for selfish motives. By the use of specific economic assumptions and analytical techniques, it was shown that this influence of revenue sharing causes the supply function of a public service such as fire protection to be more responsive in terms of increasing the quantity and quality of the output supplied of the public service. The improvement of the level of public services in a community improves the quality of life for the citizens, but more importantly, this improvement may provide the needed emphasis for a sustained period of economic development. Employment providing industries are attracted to communities with good public services, and in particular, a high level of fire protection service.

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CHAPTER I

INTRODUCTION

The cutting edge of any effort to solve pressing social problems is generally at the local level--in counties, towns, and cities. In Tennessee, for example, local communities have borne most of the responsibility for the actual delivery of indispensible public services such as health care, education, police protection, and fire protection. These public services have been provided for, wholly or in part, by the expenditure of tax revenues and by the voluntary effort of citizens. In spite of these efforts, local revenue sources have been unable to keep up with the increasing demand for and cost of delivering local public services. The tendency is for demand and cost to increase faster than available supply and revenue.

One of the most important and highly visable of the public services displaying this imbalance between demand and supply is fire protection. Fire protection is a public service that plays a unique role protecting human life and property in a community. Recent studies indicate that fire protection is one of the key community characteristics in the plant location and expansion decisions made by industrial leaders [10, 55], yet fire protection services are recognized to be severely inadequate in the rural areas of Tennessee [3]. For these reasons, the specific public service to be analyzed in this study is fire protection. Improvement of this vital public service will help to promote community development and to provide a better quality of life for people in small communities and rural areas of the State.

The Problem

The problem faced by local government officials is to maintain and/or increase the quantity and quality of local public services in the face of a generally unfavorable financial situation. This issue, as it relates to the delivery of fire protection services, will be the focal point of the theoretical and policy considerations found in the study.

To help provide a solution to this problem of resource allocation in the public sector, three areas of concern are in need of extensive exploration: 1) the relationship of cost to quality and quantity of fire protection services; 2) the impact of the federal revenue sharing program on the cost and supply of fire protection services; and 3) the imputing of an economic value to the voluntary effort used to deliver fire protection services to small communities and rural areas. With these areas of concern in mind, an analysis of the cost of supplying fire protection services would provide information that can be used at all levels of the political process to make the kind of decisions necessary to arrive at a solution for this critical problem.

Purpose and Objectives

The overall purpose of this study is to gain a fuller understanding of the economic costs of supplying fire protection services to the smaller communities and rural areas of Tennessee. The specific objectives are:

1) To discuss the theoretical issues relevant to the economic analysis of the cost and supply of a public service and to examine

topics of importance to the economic analysis of fire protection.

2) To specify and analyze models of the total and average cost of supplying fire protection services.

   a. To incorporate within the cost models a measure of quality and an imputed value for voluntary effort.

   b. To determine the existence and magnitude of economies or diseconomies of size associated with the cost of supplying fire protection services.

3) To delineate a supply function for fire protection services.

The results obtained by meeting the objectives should be of value to public policy makers and government administrators. At the local level, the analysis will provide needed information on the cost of supplying fire protection services, the presence of economies or diseconomies of size, and the general setting of fire protection delivery. At the state and federal level, a more comprehensive understanding of the cost associated with voluntary effort may be used to develop a more equitable criteria for the distribution of intergovernmental transfers of revenue from the state and federal governments to local jurisdictions. Additionally, the specifications of a cost model and the delineation of a supply function for fire protection services will contribute to a more thorough understanding of a relatively unexplored, but important topic in public economics.

Organization of the Study

Following the introductory remarks of Chapter I, a discussion of the issues in public economics that have relevance to this research is

presented in Chapter II. This examination of viewpoints is offered for the purpose of outlining the theoretical direction found in the actual analysis. Chapter III is comprised of pertinent information about the setting in which fire protection services are supplied. A general economic model of the cost of supplying fire protection services is specified in Chapter IV, including information on specific variables and special topics necessary to the full understanding of the model. Primary and secondary data sources are discussed in Chapter IV also, with commentary on the statistical framework used in the analysis. Chapter V contains a description of the actual analysis of cost and supply including the empirical models, the analytical methods, and the statistical results. Conclusions are summarized in Chapter VI with some thought given to possible directions for future research.

CHAPTER II

PUBLIC ECONOMICS: SOME THEORETICAL ISSUES INVOLVING THE COST AND SUPPLY OF A PUBLIC SERVICE

> To the theorist, the theory of public finance is but part of the general theory of government. And at this frontier, the easy formulas of classical economics no longer light our way.
>
> Paul A. Samuelson

Margolis has suggested that the increased interest in the study of government by economists has given birth to a new field of endeavor that could appropriately be called Public Economics [30]. This name reflects the move away from the more narrow types of public finance research issues such as tax incidence and expenditure analysis to the broader approach of applied economics which utilizes the concepts of efficiency and equity as they apply to the political process. There are two main reasons for this change according to Margolis: 1) Long the leading "growth" sector of the economy, state and local governments have shown a dramatic increase in financial growth. Annual rates of expansion have been around 14 percent in recent years. This financial growth far exceeds the increases in other major sectors of the economy. 2) Public sector research has been spurred on by the increased involvement of the economists at all levels of government operation and by the increased awareness of the general public on economic issues.

Regardless of the reasons for the increased interest or the name placed on the economics of the public sector, the warning that Samuelson [44] gives us has strong implications for those public sector economists

who are rigid in doctrine and inflexible in thought. The tools of the trade do remain basically the same. The results depend upon the skill of the worker as he adapts these tools to new circumstances.

Demand and Supply Relationships in Public Service Analysis

In the case of public goods, the market adjustment for demand and supply exists, but only as a part of the complex decision making matrix known as the political process. This political process or intermediation encompasses the legal decisions of formal government bodies, and the informal and intricate pressures of leadership, parties and interest groups. All of these mediate between the "demands" of citizens and the ultimate tax and expenditure decisions that "produce" a supply of public services [4] (Figure 2.1).

As for the demand schedule of a public service, economists have attempted to relate the analysis to individual preferences as in the case of private goods. However, as with the supply schedule for public services, the political process superimposes itself upon the determination of demand. Individual customers (citizens) neither bid for a given supply nor decide what quantity to purchase at a given price. Birdsall [4] writes that the individual expresses his demand for public services through political action. He does this by voting for representatives and referenda, and by less formal action such as letterwriting, lobbying, and outright bribery. There are many citizens who consume various public services and many who help pay for them. In addition, these groups may not overlap completely in that those who pay for the public services may not necessarily be the ones who consume the

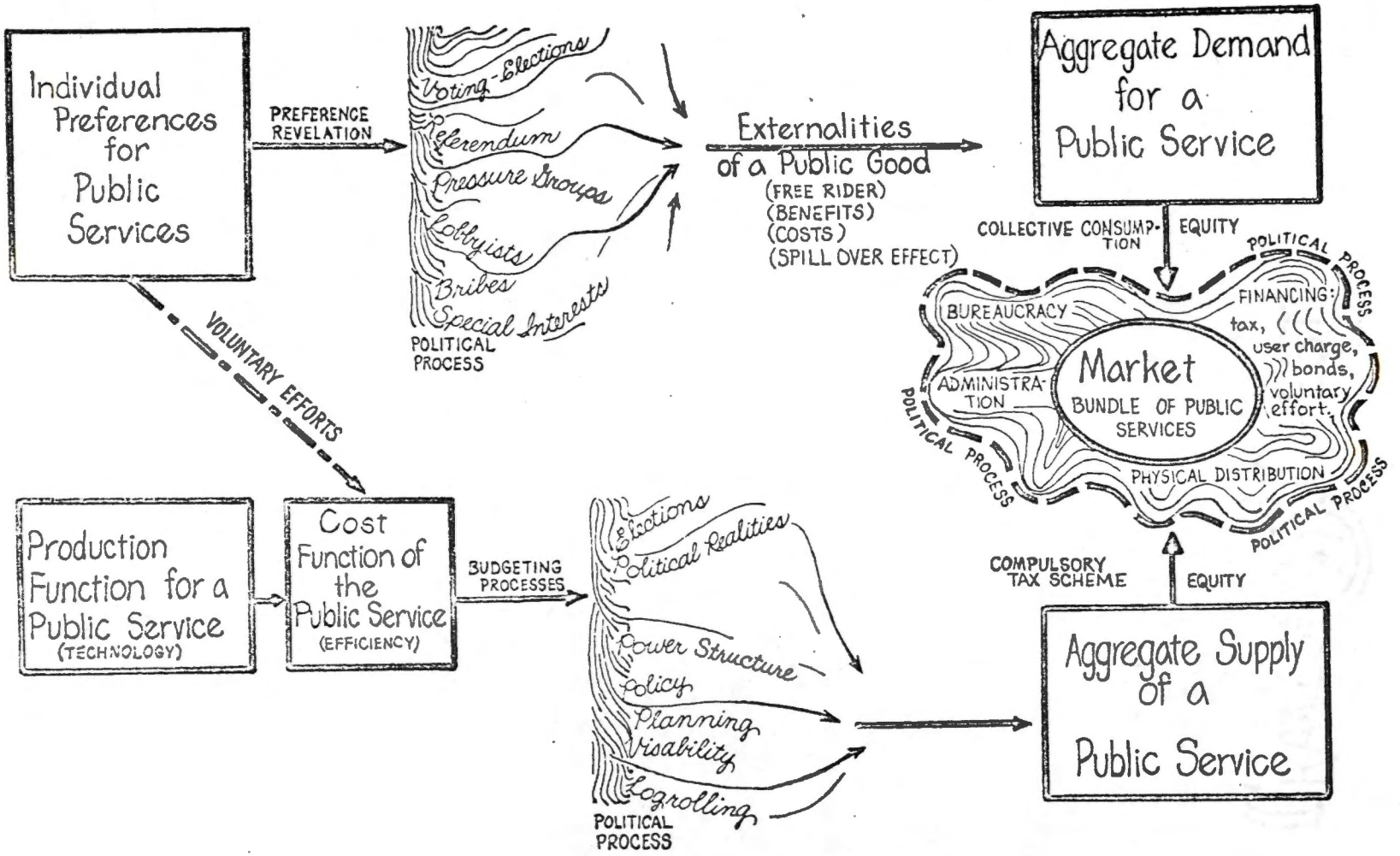

Figure 2.1. A framework for the economic analyses of a public service.

public service. Thus, there are many varied demand functions in the market. The aggregation of these demands may be reflected directly by the voting decisions of elections and referenda. These comments need to be tempered by the discussions of Kenneth Arrow in Social Choice and Individual Values [2] and those of James Buchanan and Gordon Tullock in The Calculus of Consent [7].

Margolis [30] states that need rather than demand has been the more traditional basis of planning for public services. The economist's focus, however, has been on the utility of individuals. The difficulty with this approach is that there is no procedure by which to signal the decision makers that the benefit of an increment of output is greater than the cost of that increment. The benefit of an increment is the sum of benefits received by each member of the community. Since it is likely that a reasonably large number of persons will share in public services via the "free rider" effect, it is argued that the public services will be undersupplied. In other words, the true demand for the service will not be revealed by the consumers. The same difficulties hold in the case of political decisions on any type of public service which is provided without a revealed price per unit of output.

Musgrave [32] and Hirch [18] state that the determinants of supply are the same as the determinants of cost, and that, in the normative model, the two would collapse into one, as public services are supplied at cost. Some economists argue, however, that in public economics the connection between marginal cost and the supply

schedule of a public service rests at best on shaky ground. First of all, one has no assurances that the suppliers of public services select least-cost combinations of resource inputs to produce public services. In fact, one may assume with some assurance that least-cost efficiency should not be expected. This is due to such political process characteristics as risk avoidance, interest in the total budget, inclination toward labor intensive operations, problems of distribution inherent in a public good, a planning horizon that extends in many cases only to the next election, and at times, incompetence. Secondly, public services are offered in a market with strong monopolistic characteristics [18].

To summarize, one must remember that supply depends upon the goals of government, many of which are rather complicated and often conflicting; that political intermediation confuses the issue of supply analysis in the public sector; and that one may not be able to rely entirely on the theoretical relationship between marginal cost and supply, at least in a perfectly competitive sense.

This study assumes that the distinction between the marginal cost of a public service and its supply schedule may be found in the response pattern of the political process. Brunn [6] argues that the final decisions on supply are dependent upon the relation of consumers, taxpayers, and politicians to the cost schedule of a public service. The actual solution may lie in some sort of quasi-supply curve that is modified with respect to the political process much the same way that Friedman [15] modified the firm marginal cost curves to take into

account the affect of risk and uncertainty on the supply schedule. For example, one might hypothesize that with the introduction of an exogenous variable such as revenue sharing, the risk and uncertainty for local politicians desiring to commit public funds to increase the supply of fire protection services would decrease. Thus, one may observe and show that the supply function for fire protection services has been modified by a factor in the political process to become more elastic in nature. This type of flexible analysis, with empirical evidence, would help to push the theoretical frontier of Public Economics toward a firmer definition of supply in the public sector.

The Direction of the Study

The direction of the study is guided by traditional economic and statistical considerations. By application of conventional economic tools, valid and useful information can be obtained on a specific public service. Historically, most efforts to understand the economics of public services have been handled as expenditure per capita studies. This has led to a great deal of confusion relative to creating a sound theoretical and empirical economic framework capable of generating policy recommendations. The need is to explain differences in quantity and quality levels in terms of both cost and supply factors always being careful to avoid confusing the determinants of cost with the determinants of demand. Hirsch [17] agrees, writing that the lack of separation in the factors of cost and demand that is observed in general expenditure models has led to considerable confusion.

By separating out the factors of cost (supply) and demand, an analysis would conform more rigoriously to the traditional theoretical framework of economic theory. In addition, a strict separation of factors may contribute insights into the nature of consumer (citizen) behavior as it relates to the demand for public services, and the nature of the important political process variable as it relates to both the demand for the supply of public services.

Musgrave [32] cautions economists working on public service research to define properly what it is they wish to measure. On the supply side, one has:

1) The production function which expresses the technical relationship between factor inputs and product outputs. It is an engineering relationship, but highly important for the public service problem because it deals with economies of scale, both with regard to service levels (for a given service region) and service regions (for a given service level).

2) The cost function, which for given factor prices and production functions, permits us to determine the least cost (involving the optimal combination of factors) at which a given output can be produced. Note that this function relates to the supply side problem only. It has nothing to do with consumer evaluation or demand.

On the demand side, one has:

3) The preference patterns of individual consumers, telling us how they would wish to allocate their income between different products (public and private), given various relative prices.

In the context of the private market, we can readily go beyond this and determine 4) the supply and 5) demand schedule for the market. The supply schedule in a competitive market is derived from the cost functions of the firms operating under profit maximization. The demand schedule is obtained by aggregating the demands for output as shown by preference functions subject to budget constraints of individual consumers. Or, alternatively, both schedules are derived empirically (with some difficulty, to be sure) by observing market transactions over time. Musgrave suggests that 1) production functions, 2) cost functions, and 3) preference patterns of public services pose no particular conceptual problems, each being similar in approach to that of private goods. However, with regard to 4) supply and 5) demand schedules for public services, there are definite analytical and conceptual problems unique to the public sector.

Musgrave recommends that public service analysis should begin with attempts to derive cost functions for specific public services such as fire protection or health care [32]. This effort requires an understanding of the production process and the ability to measure units of output and quality levels. This is essential for dealing with problems of efficiency related to input substitution and economies of size. Without this measurement ability, the calculation of average cost (and the related economies of size) and the delineation of marginal cost (and the related supply function) would be impossible. Musgrave concludes with the statement that this is surely one of the most interesting directions for empirical research in the area of Public Economics.

CHAPTER III

TOPICS OF IMPORTANCE TO THE ECONOMIC ANALYSIS OF FIRE PROTECTION SERVICES

The formulation of an empirically sound economic model requires extensive knowledge about the characteristics, practices, related institutions, and organization of the public service being analyzed. "Knowledge of the industry" is the first rule for economic model building in both the private and public sectors.

Knowledge of the setting in which a public service is delivered has special significance due to the unique issues that are encountered in the public sector. Such issues as the measurement of the quality and quantity of output and the assessment of the political setting must be dealt with to have a full understanding of the setting in which a public service is delivered. Only with this understanding can effective and appropriate economic models be specified and analyzed for individual public services.

The Survey of Fire Chiefs

One of the most important sources of information on the delivery of fire protection services at the local level is the primary officer of the fire department--the fire chief. Consequently, the fire chiefs of departments serving smaller municipalities and rural communities were surveyed to provide general information on the delivery of fire protection

services and primary data needed for the statistical analysis of the economic models.[1]

Information from the fire chiefs was obtained on the following specific topics: 1) the Insurance Services Office (ISO) evaluation system,[2] and other indicators of quality performance for a fire department, 2) the political climate at the local level, and 3) the use of revenue sharing funds for fire protection. The first topic deals with the problem of measuring the quality of output. The second and third topics attempt to shade light on some aspects of the political environment as it affects the delivery of fire protection services. Each of these topics has a direct and/or indirect relationship to the empirical analysis of this study, and was influential in the formulation and estimation of the economic models.

---

[1]A list of fire departments and fire chiefs was obtained from The University of Tennessee Institute of Public Service. All fire departments (fire chiefs) in the state, with the exception of those within the jurisdiction of the metropolitan governments of Memphis, Nashville, Knoxville, and Chattanooga, were mailed a questionnaire with a followup two weeks later in June, 1975. Of the 276 fire chiefs contacted, 111, or 40 percent, responded. A copy of the questionnaire may be found in Appendix A. The total cost, quantity of output, and delivery environment associated with the four metropolitan departments mentioned above are vastly different from the remaining departments in the state. Because of these differences, and due to the small community and rural areas focus of this study, these departments were not included in the analysis. The primary data related to specific variables in the actual analysis are discussed in detail in Chapter IV.

[2]The Insurance Services Office (ISO) of Tennessee is a private organization supported by insurance companies and regulated by the Tennessee State Department of Insurance. One of the responsibilities of the ISO is to evaluate the performance of fire departments for the purpose of assigning fire insurance rate structures to communities in the state. This evaluation is based upon water supply, fire department, fire service communication and fire safety control. For a more detailed look at this ISO evaluation, refer to Appendix B and Appendix C.

Answers given to questions on these topics were classified on the basis of population and manpower categories (Table 3.1). Each of these categories reflected natural divisions of budget levels, costs, output levels, service delivery environments, and manpower mixes. The population groups were based upon the estimated population protected: 1) 20,000 or more; 2) 10,000 to 19,999; 3) 2,500 to 9,999; and 4) less than 2,500. The manpower groups were based upon the manpower mix as represented by the ratio of professional firemen to the total number of firemen in a department. These groups were: 1) all (100 percent) professional; 2) 50-99 percent professional; 3) 1-49 percent professional; 4) all (100 percent) voluntary.

ISO Evaluation of Fire Departments

The ISO grading system is a controversial topic in the discussion of fire protection services, yet 58 percent of the fire chiefs responding felt that the grade assigned to fire protection services for their communities by the ISO was a true reflection of the fire prevention and fire suppression capabilities of the fire departments under their jurisdiction. Of the 79 fire chiefs responding to the question of whether the ISO grading system needs improving, 75 percent indicated that improvement was necessary (Tables 3.2 and 3.3).

The fire chiefs were asked to rank five indicators of quality performance for fire departments. Seventy-one of the fire chiefs in the survey ranked the five choices from a best indicator (1) to a poorest indicator (5) of fire department performance. The choices included: 1) ISO rating system grade number, 2) response time (the elapsed time

TABLE 3.1

NUMBER OF FIRE CHIEFS RESPONDING TO THE SURVEY, BY POPULATION AND MANPOWER CATEGORIES, TENNESSEE, 1975

Manpower Category/ Population Category	Number of Fire Chiefs Responding to Survey					
	100% Professional	50-99% Professional	1-49% Professional	100% Voluntary	Total	Percentage of Total
20,000 or more	7	1	3	1	12	11
10,000 to 19,999	2	11	3	4	20	18
2,500 to 9,999	0	5	16	19	40	36
Less than 2,500	0	0	2	37	39	35
Total	9	17	24	61	111	
Percentage of the Total Response	8	15	22	55		100

TABLE 3.2

EVALUATION OF THE INSURANCE SERVICE OFFICE GRADING SYSTEM, BY FIRE CHIEFS RESPONDING TO THE SURVEY, BY POPULATION CATEGORY, TENNESSEE, 1975

Population Category	Does the ISO Grade Reflect True Performance			Does the ISO Grading System Need Improvement		
	Yes	No	N.R.[a]	Yes	No	N.R.[a]
	Number of Responses					
20,000 or more	7	5	0	10	2	0
10,000 to 19,000	14	6	0	9	3	8
2,500 to 9,999	19	17	4	24	8	8
Less than 2,500	18	14	7	16	7	16
Total	58	42	11	59	20	32
Number of Responses	58	42		75	25	
Percentage of the Total Response						

[a]Number of nonresponses to each specific question.

TABLE 3.3

EVALUATION OF THE INSURANCE SERVICE OFFICE GRADING SYSTEM, BY FIRE CHIEFS RESPONDING TO THE SURVEY, BY MANPOWER CATEGORY, TENNESSEE, 1975

Manpower Category	Does the ISO Grade Reflect True Performance			Does the ISO Grading System Need Improvement		
	Yes	No	N.R.[a]	Yes	No	N.R.[a]
	Number of Responses					
100% Professional	7	2	0	5	1	3
50-99% Professional	14	2	1	9	3	5
1-49% Professional	11	12	1	11	4	3
100% Voluntary	26	26	9	28	12	21
Total	58	42	11	59	20	32
Number of Responses	58	42		75	25	
Percentage of the Total Response						

[a]Number of nonresponses to each specific question.

between the first report of a fire and arrival on the scene), 3) population protected per dollar of fire department expenditure, 4) fire suppression effectiveness (minimizing damage spread after arrival), and 5) the number of fulltime professional firemen in a department.

The ISO rating is a convenient indicator of overall quality performance and has been accepted by many professionals as the best because it has embedded within it the most important considerations for evaluating fire protection services. However, the fire chiefs rated this indicator lower than the others. The fire chiefs ranked the quality indicators in the following order: 1) response time, 2) fire suppression effectiveness, 3) per capita expenditure for fire protection services, 4) number of professional firemen, and 5) the ISO grade (Tables 3.4 and 3.5).

Response time was picked by 71 percent of all-professional fire department chiefs as the best indicator. Response time and fire suppression effectiveness were selected equally as the best indicator by all-voluntary department chiefs. Fourteen percent of the all-professional department chiefs regarded fire suppression effectiveness as the best indicator while 71 percent of them scored it as the second best. The ISO grade was picked as the poorest or next to the poorest indicator by the fire chiefs in all the manpower categories. The number of professional firemen in a department and the level of per capita expenditure were regarded by most of the fire chiefs without strong feelings one way or the other.

TABLE 3.4

CHOICES BY FIRE CHIEFS OF THE BEST INDICATOR OF QUALITY PERFORMANCE FOR A FIRE DEPARTMENT, BY POPULATION CATEGORIES, TENNESSEE, 1975

Population Category	Indicators of Quality Performance[a]				
	Response Time	Fire Suppression Effectiveness	Per Capita Expenditures	ISO Grade	Number of Professional Firemen
	Frequency of Choice				
20,000 or more	5	3	1	0	0
10,000 to 19,000	6	9	1	1	1
2,500 to 9,999	14	7	1	1	3
Less than 2,500	8	8	2	0	0
Total	33	27	5	2	4
Percentage of Total Response	47	38	7	3	4
Mean value[b]	1.09	1.26	2.21	2.75	2.26

[a]As indicated by the 71 fire chiefs who responded to the question.

[b]As represented by a scale of 1 (Best) to 5 (Poorest).

TABLE 3.5

CHOICES BY FIRE CHIEFS OF THE BEST INDICATOR OF QUALITY PERFORMANCE FOR A FIRE DEPARTMENT, BY MANPOWER CATEGORIES, TENNESSEE, 1975

Manpower Category	Indicators of Quality Performance[a]				
	Response Time	Fire Suppression Effectiveness	Per Capita Expenditures	ISO Grade	Number of Professional Firemen
	Frequency of Choice				
100% Professional	5	1	1	0	0
50-99% Professional	5	6	1	1	2
1-49% Professional	10	7	1	1	0
100% Voluntary	13	13	2	0	2
Total	33	27	5	2	4
Percentage of Total Response	47	38	7	3	6
Mean value[b]	1.09	1.26	2.21	2.75	2.26

[a]As indicated by the 71 fire chiefs who responded to the question.

[b]As represented by a scale of 1 (Best) to 5 (Poorest).

Strong opinions were voiced by fire chiefs who commented on the ISO grading system. Specific suggestions included:

1) A need to consider more adequately the differences between rural and urban fire protection requirements relative to equipment, water supply, and manpower.

2) A need to consider more fully fire prevention efforts of a fire department and, a necessity for providing incentives for this activity.

3) A need to evaluate the effectiveness of volunteer firemen at a more equivalent ratio with professional firemen recognizing the training, performance, and firefighting experience of today's volunteer fireman.

4) A need on the part of the fire chiefs for more open and informative communications from the ISO about evaluation procedures, policies, and actual evaluation of fire departments in individual communities.

5) A need to develop and use better indicators of quality performance for evaluation purposes such as response time and fire suppression effectiveness.

6) The fire chiefs felt that more frequent fire department evaluations would be helpful.

7) The ISO grading system should be made more uniform statewide, and eventually national standards should be set for this evaluation process.

The following statements are additional comments about specific issues relating to the ISO evaluation system. A fire chief in one of the larger municipalities suggested that "all public fire alarm pull boxes should be abolished due to the large number of false alarms these boxes encourage in most cities." One small town fire chief suggested that the numbering of houses be dropped as a requirement for moving from a Class 10 rating to a Class 9 rating. "In a small town, we all know where everyone lives. The number on the house has nothing to do with our ability to fight a fire!" A fire chief, who leads a

department responsible for a large population scattered over a wide rural area, suggested that "the ISO weigh more heavily special equipment used in rural areas such as mini-pumpers and tanker trucks". The argument was that certain types of equipment help to neutralize the detrimental effects that distance and lack of water systems have on fire departments.

Many fire chiefs feel that the ISO grade is a fairly good indicator of overall department performance, but most fire chiefs feel that the system needs improving. The fire chiefs responsible for the voluntary departments in the smaller communities were concerned because the full capabilities of their departments were not being recognized by the ISO. The nonresponse given to the ISO related questions was most prevalent among the all-voluntary department chiefs. This may indicate a general lack of understanding of the ISO mode of operation on the part of the nonprofessional fire chiefs. What is suggested by these results is the need for the ISO grading system to have incorporated in it indicators of individual quality performance such as actual response time and fire suppression effectiveness.

Political Environment. An understanding of the political environment is necessary to evaluate the cost and supply aspects of the delivery of a public service such as fire protection. In this context, the political environment can be interpreted as the environment in which the political process functions. One needs to look at the amount of cooperation and support that fire departments receive from appointed officials, elected officials, and the general public. Questions

were asked of the fire chiefs to help assess the dynamic and static aspects of the political process in which policy decisions that affect the quality and quantity of fire protection services are made (Tables 3.6 and 3.7).

Eighty-two percent of the fire chiefs responding felt that local community decision-makers cooperate with fire protection officials on matters concerning fire departments such as planning for water systems, purchasing new fire fighting equipment, and mapping out the total department budget. The greatest cooperation was observed in the 2,500 to 9,999 population protected category, and the 1 to 49 percent professional manpower category where 90 and 100 percent, respectively, responded "yes" to the question on the existence of local government cooperation.

A specific question asked that intended to ferret out the attitude of county officials toward the problem of fire protection in the outlying areas of the rural counties was: "Do the elected county officials actively support fire protection services for the rural areas of the county?" Fifty-five percent of the 99 fire chiefs responding answered "no" to this question. Interestingly enough, the same fire chiefs who viewed local cooperation as being favorable were inclined to respond negatively to this question. Fifty-three percent of the fire chiefs in the all voluntary manpower category and 65 percent of the fire chiefs commanding departments in the less than 2,500 population protected category responded "no" to this question. This negative response may indicate that there is a need for more attention to be

TABLE 3.6

EXISTENCE OF LOCAL COOPERATION, OFFICIAL SUPPORT, AND PUBLIC SUPPORT BY POPULATION CATEGORIES, SURVEY OF FIRE CHIEFS, TENNESSEE, 1975

Population Category	Local Cooperation			Official Support			Public Support		
	Yes	No	N.R.[a]	Yes	No	N.R.[a]	Yes	No	N.R.[a]
	Number of Responses								
20,000 or mote	10	2	0	7	5	0	8	4	0
10,000 to 19,999	16	4	0	11	7	2	17	3	0
2,500 to 9,999	35	4	1	15	20	5	37	3	0
Less than 2,500	25	9	5	12	22		24	11	4
Total	86	19	6	45	54	12	86	21	4
Number of Responses As a Percentage of the Total Response[b]	82	18		45	55		80	20	

[a]Number of nonresponses to each question.

[b]There were 105, 99, 107 responses, respectively, by topic.

TABLE 3.7

EXISTENCE OF LOCAL COOPERATION, OFFICIAL SUPPORT AND PUBLIC SUPPORT BY MANPOWER CATEGORIES, SURVEY OF FIRE CHIEFS, TENNESSEE, 1975

Manpower Category	Local Cooperation			Official Support			Public Support		
	Yes	No	N.R.[a]	Yes	No	N.R.[a]	Yes	No	N.R.[a]
	Number of Responses								
100% Professional	6	3	0	7	5	0	8	4	0
50-99% Professional	15	2	0	11	7	2	17	3	0
1-49% Professional	23	0	1	15	20	5	37	3	0
100% Voluntary	42	14	5	12	22	5	24	11	4
Total	86	19	6	45	54	12	86	21	4
Number of Responses As a Percentage of the Total Response[b]	82	18		45	55		80	20	

[a]Number of nonresponses to each specific question.

[b]There were 105, 99, 107 responses, respectively, by topic.

given to rural fire protection on the part of elected county officials.

Over 80 percent of the fire chiefs in the all-voluntary and mixed manpower categories felt that the general public actively supported improved fire protection services for their respective communities. However, only 67 percent felt that this was the case for the all professional fire departments. In the 20,000 or more category, where a large percentage of the departments were all professional, public support was felt to be missing in 33 percent of the cases. The two middle population protected categories showed the highest percentage of positive response. Fire chiefs in the very small communities gave a 69 percent positive response indicating concern on the part of the public for improved fire protection services.

To summarize, local officials cooperate with the fire chiefs to plan for and budget fire protection services in the community. However, elected county officials do not seem to respond adequately to the need for expanded fire protection in the outlying and more rural areas of the counties. Public support for improved fire protection services in general is at a very high level in all of the population protected categories. This public support does weaken slightly, however, for the more removed all-professional staffed departments and, also, in the small communities where the felt need for fire protection services may not be as intense as in the larger communities.

Revenue Sharing. The availability of revenue sharing funds for communities in Tennessee has made an impact on fire protection services in the state. Fifty-seven percent of the fire departments responding

indicated that revenue sharing funds have been used for fire protection purposes since their communities began receiving these intergovernmental transfers of revenue.

In the departments that protected 20,000 or more people, 75 percent used revenue sharing funds. This funding, however, was used by relatively few of those departments that protected populations of less than 2,500. Of the 39 departments in this category, only 46 percent reported using revenue sharing funds (Tables 3.8 and 3.9).

Of the actual dollars spent, the most frequent investment was for new equipment. The level of these investments ranged from $150 to $68,182 per fiscal year for a single fire department. Total dollars of revenue sharing funds spent on new equipment was $1,030,520 from the first entitlement period (1972) through fiscal year 1974-75 for the 59 departments that reported spending funds for this purpose. The most popular choices for investment were the large ticket items, mainly pumper and tanker trucks, many priced between $40,000 and $55,000.

Ten fire departments used the additional revenue for their communities to offset the ever increasing cost of labor. The range of these expenditures during the three-year period under consideration was from $420 to $250,190. The total amount of revenue sharing funds spent on labor for this three fiscal year period (1972-75) was $719,895. It should be noted that this figure was dominated by two departments that used a total of $466,190 for this purpose.

Eight fire departments in the same three-year period used this opportunity to improve old structures or to build new structures with

TABLE 3.8

NUMBER OF FIRE DEPARTMENTS USING REVENUE SHARING FUNDS BY POPULATION CATEGORY, SURVEY OF FIRE CHIEFS, TENNESSEE, 1975

Population Category	Were Revenue Sharing Funds Used for Fire Protection Purposes		
	Yes	No	Nonresponse
20,000 or more	9	3	0
10,000 to 19,999	10	9	1
2,500 to 9,999	22	18	0
Less than 2,500	18	15	6
Total	59	45	7
Number of Responses As a Percentage of the Total Response	57	43	--

TABLE 3.9

NUMBER OF FIRE DEPARTMENTS USING REVENUE SHARING FUNDS BY MANPOWER CATEGORY, SURVEY OF FIRE CHIEFS, TENNESSEE, 1975

Manpower Category	Were Revenue Sharing Funds Used for Fire Protection Purposes		
	Yes	No	Nonresponse
100% Professional	6	3	0
50-99% Professional	12	5	0
1-49% Professional	13	11	0
100% Voluntary	28	26	7
Total	59	45	7
Number of Responses As a Percentage of the Total Response	57	43	

the revenue sharing money made available. Of these eight, only three made a substantial investment of $25,000 or more. The total amount spent was $181,015 (Table 3.10).

In summary, the all professional fire departments protecting the higher population categories had more revenue sharing funds committed to them than the more rural all-voluntary fire departments that protected populations of less than 2,500 people.[3] Of the revenue sharing dollars used, most were invested in capital expenditures such as new fire trucks and new structures. This reflects the fact that the Revenue Sharing Act itself is limited in duration and cannot be depended upon as a continuing source of funds for ongoing cost such as labor or for new programs. In total dollar terms, $1,931,433 have been spent on fire protection services by the 111 fire departments that responded to the survey. This represents 1 1/2 percent of the total amount of revenue sharing funds received by Tennessee from the initial entitlement through the Fifth Period (1972 through fiscal year 1974-75).

Relevance to the Study

Chapter III contains a review of some of the important topics in the setting of fire protection delivery. The opinions are those of the fire chiefs of Tennessee who responded to the survey. This knowledge and information will be applied in combination with a general economic

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[3]This conclusion may be a reflection of the fewer dollars of revenue sharing funds received by the smaller communities; most investments in fire protection require a larger initial sum than may be available to the smaller communities.

TABLE 3.10

REVENUE SHARING FUNDS SPENT ON FIRE PROTECTION BY FISCAL YEAR AND PURPOSE, SURVEY OF FIRE CHIEFS, TENNESSEE, 1975[a]

Fiscal Year	72-73	73-74	74-75	Total 72-75
New Equipment	$249,957	$485,012	$295,551	$1,030,520
Structures (Repair and Now)	N.A.[b]	N.A.	N.A.	$ 181,015
Labor	N.A.	N.A.	N.A.	$ 719,898
Total	N.A.	N.A.	N.A.	$1,931,433

[a]The 59 fire departments that indicated a use of revenue sharing funds for fire protection purposes are included in this table.

[b]N.A. - Not available.

model of cost and supply to obtain a more useful and appropriate analysis of fire protection services.

CHAPTER IV

AN ECONOMIC AND STATISTICAL FRAMEWORK

An economic model of the cost of supplying fire protection services is presented that incorporates an imputed value for voluntary effort. The basic concern is with those variables that are hypothesized to be determinants of cost. A total cost model is specified with consideration given to the measurement of quantity and quality of output, and the definition of the environment in which this public service is delivered. The sources of primary and secondary data are presented followed by a brief discussion of statistical considerations.

A General Economic Model

Hirsch [12] states that the cost of supplying a public service is affected by the following categories of variables: 1) the quality of the service delivered, 2) the quantity of the service delivered, 3) the prices of the factor inputs, 4) the environment under which the service must be delivered, and 5) the state of technology. Thus, generalized cost function for a public service may be represented as follows:

> Total cost for a public service = f (the quality of the public service delivered, the quantity of the public service delivered, the costs of the inputs, the environmental variables that affect the particular public service, and technology).

Within these categories specific variables are hypothesized to influence the level of cost for supplying a public service on the part of a local community. A general discussion of each category is necessary to understand fully the final selection of variables used in the analysis.

A major obstacle in determining an expenditure function for many public services is the delineation of a variable that represents a measure of output quality. In the case of fire protection, Hitzhusen [21] states that output quality may be defined in terms of how well the people and property of a community are protected. Hitzhusen [21] and Pickett [35] feel that the Insurance Service Office (ISO) schedule for grading municipal fire defense and setting insurance rates is the best indicator of overall quality and performance.

The output quantity of fire protection may be defined in terms of the total number of people protected per unit of fire service. Hitzhusen [21] argues that a single proxy variable representing both population and property would be ideal. Such a variable, however, would be extremely difficult to develop because it would require a common denominator for human lives and real property.

In a model of fire protection cost and supply, some rather untraditional aspects of the traditional input factors of labor, capital, land, and management must be considered. First, Bradford, et al., [5] state that while increasing use is made of sophisticated capital equipment in the provision of fire protection, the fact is that the major part of spending for fire protection is for manpower. Second, Hirsch [18] suggests that local governments may be constrained from attaining the least-cost combination of factor inputs. In part, this is due to the reluctance of the local electorate to approve bond issues on tax increases necessary for financing capital expenditure programs. The result may be that the local government must adopt more

labor intensive techniques of production for fire protection than would otherwise be desired. Third, capital is not represented specifically in total cost because of the near impossibility of obtaining data that are valid, consistent and comparable over the range of the sample. The importance of the labor input implies that, except in isolated years, the capital cost portion of the total budget is overshadowed by the cost of labor per unit of fire protection produced. This opinion is substantiated in the empirical work by Pickett [35] and Hitzhusen [22]. Fourth, with respect to the expenditure function of fire protection, land does not assume a major role. Most frequently, fire departments are located on land owned by government entities. Finally, the management input may be included with the labor input. Since labor inputs may be denoted in dollar terms, total wages paid include increasing incremental payments to the fire chief and other officers of a fire department who perform the managerial functions. The largest cost factor in public fire protection is the cost of manpower or of man-hours devoted to fire protection work. According to Hitzhusen [22] this constitutes approximately 95 percent of the cost of a public fire department. Equipment, supplies, and administration make up the remaining 5 or 6 percent of the average fire department budget. The conclusion is that the labor input is the most important cost factor in providing fire protection, and thus, the labor input will serve as a variable in the model.

Environmental determinants of cost are those factors which make it easier or more difficult for a community to provide service of a

specified quality and quantity. The environmental determinants of cost are a variety of physical, financial, social, legal, political, and economic factors that bear a direct or indirect relation to the level of public services delivered to a community. In the case of fire protection, such determinants of expenditure as housing density, population density, number of manufacturing establishments, area protected, building materials, and water system availability are important considerations.

The technology variable indicates the "state of the arts" for the production of a good or service. In the case of a public service, advances in technology may lead to changes in the production function. The analysis for this study, however, will be cross sectional, and technology is therefore assumed to be constant in the model.

With these comments in mind, the general model of total cost for fire protection service is represented as

$$E = f(P_1, P_2, Q, A, L, X_1, X_2, X_3)$$

where the variables are specified as follows:

E = that portion of the local government budget allocated to fire protection plus an imputed value for voluntary effort

P_1 = quantity of output measured by the fire chief's estimate of the total population protected by his own department

P_2 = quantity of output measured by the total assessed value of taxable property protected

Q = quality of output as represented by the Insurance Service Office (ISO) evaluation grade level for the community

A = the number of alarms per year (proxy for variable cost)

L = the percentage of full-time firemen (proxy for fixed cost)

X_1 = population density per square mile

X_2 = the total number of manufacturing establishments within the jurisdiction of the department

X_3 = revenue sharing received in year t by the local government (proxy for community tax effort and relative income).

Presented in the Hirsch framework, the variables represent a measure of quantity, quality, factor price, and the setting in which the service is delivered. These are necessary ingredients for the estimation of a cost function for a public service.

Definition of Variables

Quantity (P_1, P_2) is measured by the population protected and the value of property protected in alternative definitions of output. The primary goals of fire protection service, other than fire prevention, are first, to save lives, and second, to save property. Both of these quantity indicators are important for a correct evaluation of fire protection output. The lack of a common variable to represent human lives and property has led to the estimation of two separate measures of output.

The quality of the output proxy variable (Q) is based on the ISO rating system for evaluation of fire protection services for communities.

It is hypothesized that the cost per unit of output varies directly with the quality of the fire protection service delivered. The argument has been made that there exists a two-way causal relation between cost and quality. It is assumed in this model that cost is dependent upon a level of quality predetermined by the political process.

The number of alarms (A) was considered as a possible measure of output during the early conceptualization of the model. It was later decided to use this variable as an independent proxy for variable cost. The use of such factors of production as gas and oil, and the cost of maintenance is hypothesized to vary directly with the number of alarms answered that are related to fire suppression.

As indicated earlier, the most important factor of production in relation to the cost of supplying fire protection service is labor. Labor is represented in the model by the percentage of full-time paid firemen (L) which is assumed to be a proxy for fixed cost.[1] It is hypothesized that the percentage of full-time paid firemen varies directly with cost and directly with the quality of fire protection delivered.

The environmental variables represent the characteristics that are a part of the physical and economic setting in which the fire protection is delivered. The environmental variables are represented by the physical setting variables, that is the density for square mile of

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[1]The use of labor as a fixed input is an unusual approach. Further references are made by way of explanation throughout the study.

population in a community (X_1) and the number of manufacturing firms variable (X_2), and the economic variable, the allocation of general revenue sharing funds to the community (X_3). These variables are a measure of the difficulty or ease under which the fire protection service must be delivered. Costs are hypothesized to vary directly with each of these variables, with one exception. The exception is that in the case of extreme rurality, where the population density is very low, diseconomies of size are hypothesized to exist, thus increasing the per unit cost of output. In addition, the population density variable is assumed to be a proxy indicator of the density of housing and the degree of rurality of a community.

The revenue sharing funds received by a community (X_3) are hypothesized to influence positively the quality and quantity of fire protection services supplied to a community. The five year limitation on the present Revenue Sharing Act has worked as an incentive for local governments to invest in capital equipment, and indications are that many communities are buying fire fighting equipment with these revenues. In addition, many influences are hypothesized to be embedded within the revenue sharing variable. The total amount of revenue sharing funds entitled for a local government is based upon a three-factor allocation formula.[2] These factors are total population, the general tax

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[2]Interpretation of Public Law 92-512, 92nd Congress, H.R. 14371, October 20, 1972.

effort[3] and the relative per capita income.[4] Therefore, this economic environment variable is assumed to be a proxy for a community's capacity and willingness to provide an acceptable quantity and quality level of public service mix, including fire protection.

Length of Run

In conventional theory of the firm,[5] a distinction can be made between the short run and the long run. The short run is defined as the period of time in which certain factors of production are fixed with regard to the level of use in the productive process. Corresponding to these fixed factors are associated fixed costs. Thus in the short run, total cost is the sum of this fixed cost plus a variable cost associated with the remaining factors of production that vary with the level of output. One should remember, however, that no input is ever absolutely fixed, no matter how short the period of time under consideration. What this analytical convenience does accomplish is to remove from immediate consideration input variations that are most likely inefficient cost-wise or impractical time-wise. In like fashion, the

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[3]The general tax effort factor of any unit of local government is the adjusted taxes of that unit of local government divided by the aggregate income. Adjusted taxes are defined as the compulsory contributions exacted by a unit of local government for public purposes excluding that portion of revenues used for educational purposes.

[4]Relative per capita income is measured by the ratio of the state's per capita income to the local per capita income.

[5]C.E. Ferguson, Microeconomic Theory (Homewood, Illinois: Richard D. Irwin, Inc., 1972). The definitions above borrow heavily from Chapter 5 of this book.

long run is defined as the period of time in which all inputs are variable. The long run is a planning horizon where all possible adjustments to the production process can be made.

The distinction between short run and long run presents special, but nonconsequential problems in public economics. Any definition of length of run is dependent upon a fixity of resources in relation to time. The adjustment of the levels of resource use allocated to the public service production process is in turn totally dependent upon the possible responses found in the political process. Numerous lags and rigidities are present in this system which can be only as responsive as local conditions permit. Quite possibly, there is a "rachet effect" in the production process where the expansion path of production is more elastic than the contraction path of production. For example, new firemen may be added to a fire department more easily than others may be dismissed in the future possibly due to unions or other like pressures. Another example is where a community that is declining economically might have a higher level of public service mix than a community that is expanding economically. This is due to the previous commitment of resources that has established a "fixed plant" in the declining community that is hard to dispose of in an economic manner. (This is analagous to the capital investment of the marginal dairy farmer.) Opposite of this argument, any influence that reduces risk and uncertainty for local decisions makers i.e. revenue sharing would cause factors of production to become more variable. Under these circumstances, the expansion path of production is more elastic as the political process responds to

decrease the length of the short run.

A distinction between varying lengths of run will be used in this study for purposes of analytical convenience and compliance with convention One should note, however, that due to the overwhelming influence of the cost of labor on the total cost of fire protection (especially when an imputed value for voluntary effort is included), this distinction is of minimal influence on the analysis of cost and supply of a public service such as fire protection. In fact, Hirsch states that the distinction between fixed and variable costs, while applicable, is likely to be of relatively little consequence in empirical efforts to estimate local government costs of those local government services that are highly labor intensive [17]. Fire departments must be continuously staffed at a much higher than average level of utilization due to the random need characteristics of this type of public service.

A Special Consideration: Voluntary Effort

Organized voluntary effort to provide public services for people has a long history in the United States. Alex de Tocqueville has written that he "admires the extensive skill with which the inhabitants of the United States succeed in proposing a common object to the exertions of a great many men, and in getting them voluntarily to pursue it" [12]. Serageldin [47] estimates that the gross national product of the United States would increase by about $12.6 billion annually if voluntary production were valued at its opportunity cost.

While the economic importance of voluntary effort has been recognized, its value for delivering public services to small and rural communities has not been adequately studied. An excellent example is where voluntary labor is used to help staff fire departments in local jurisdictions. In Tennessee it has been estimated that over 80 percent of the fire departments use some form of voluntary labor. Nationally, voluntary efforts in fire protection are estimated to have an opportunity cost of $4.3 billion annually [47]. These estimates take on added meaning for delivering public services when one considers that most of the voluntary effort is in the form of labor participation by individuals, and further that the labor input is concluded to be the most important factor in the rising cost of producing government services [22].

A model of cost and supply dealing with fire protection in small communities and rural areas would be incomplete without the inclusion of an imputed value for voluntary effort. Several approaches for imputing value to this voluntary effort based upon a unit of response have been suggested by Hitzhusen [22], where the unit of response is defined as one volunteer responding to one alarm. These approaches are outlined as follows:

1) The actual call fee reported by those communities that compensate volunteers per alarm.
2) A full alternative cost concept based on the dollar value assessment of a professional fireman per alarm.
3) A modified alternative cost concept based on approach two above, modified by the ISO fire protection grading system

> "rule of thumb" that it takes approximately four volunteer firemen to equal one full-time professional fireman in effectiveness. In other words, to get this value, divide the imputed value in approach two by four.

Therefore, the total imputed value for voluntary fire protection effort in a community become the average number of volunteers responding to an alarm times the number of alarms times the dollar value assigned to each volunteer response unit.

An alternative to these approaches will be used to impute a value to voluntary effort in this study. The unit of response per alarm will be abandoned completely for the following reason. Cost per alarm is a possible proxy for variable cost, but it ignores completely the reality of the fixed cost of the labor input on a market equivalent basis. The wages of a professional fireman are paid in full regardless of the number of alarms answered.[6]

The first approach considered for imputing a market equivalent value to voluntary effort was to use the standard conversion ratio of the Insurance Services Office (ISO) rating system which equates four volunteer firemen to one professional fireman in fire fighting effectiveness [34]. Multiplying the number of active volunteer firemen in a department by the one-fourth conversion ratio gives an equivalent

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[6]The unit of response per alarm would be valid for imputing an opportunity cost to the individual who volunteers his time as a volunteer fireman. However, when the market cost equivalent of replacing volunteers with professionals is calculated, one must remember that the cost of labor remains fixed regardless of quantity of output as measured by the number of alarms.

number of professional firemen in fire fighting effectiveness. Multiplying this number by a representative annual salary level gives a total imputed value for voluntary effort.

The second approach, and the one used in this study, is based upon Recommendation No. 10 of the New Provisions of the ISO Grading Schedule [37]. This recommendation states that with proper training, equipment, and leadership, volunteer and part volunteer fire departments can perform in an equivalent manner to professional fire departments. Thus, from this recommendation, the suggestion has been made to modify the ratio of equivalence between volunteer and professional firemen from four to one to two to one. Multiplying the number of active volunteers in a fire department by the new one-half conversion ratio gives the new equivalent number of professional firemen. As stated above, multiplying this number by an annual salary level gives an imputed value for the total voluntary effort of an entire fire department.

Data Sources

Data necessary for the analysis were obtained from a combination of primary and secondary data sources. Secondary data were supplemented by primary data obtained from the comprehensive survey of fire chiefs in Tennessee described earlier. Specifically, the following data were collected: 1) the portion of the local government budget allocated to fire protection, 2) the fire chief's estimate of total population protected by each department (P_1), 3) the number of alarms directly related to fire suppression answered by the department per year (A), 4) the

number of full-time professional firemen, 5) the number of fully active volunteer firemen, and 6) the average annual salary of the paid firemen. The answers obtained were used directly or in combination with secondary data to provide values for the variables used in the empirical analysis.

Secondary data sources used to obtain values for the remaining variables were as follows. The total assessed value of real property protected (P_2) came from data obtained in the Tennessee Taxpayers Association 1973 Annual Survey of County and Town Government in Tennessee [52], and was augmented by personal correspondence with the staff of the Tennessee State Board of Equalization in Nashville. The total assessed value of real property was not available for fourteen extremely small municipalities of less than one thousand population. The quality of output proxy variable, (Q), was based upon the actual ISO grade evaluations provided by the Insurance Services Office of Tennessee in Nashville. The physical environmental proxy variables, (X_1 and X_2), were obtained from the Tennessee Statistical Abstract 1974 [53], published by The University of Tennessee Center for Business and Economic Research, and the 1975 Tennessee Manufacturers Directory published by the Tennessee Department of Economic and Community Development [51]. The revenue sharing variable, (X_3) was obtained from the Data Elements for Entitlement Period 5, published by the U.S. Department of the Treasury, Office of Revenue Sharing [11].

Statistical Considerations

The statistical models found in the next chapter are estimated by use of the Ordinary Least Squares (OLS) multiple regression technique. The general form of the regression equation is:

$$Y = a + B_1X_1 + B_2X_2 + \ldots + B_nX_n + u$$

where Y is the dependent variable, the B's are the regression parameters, a is the Y-intercept, the X's are the independent variables, and the u represents the error term. The following standard assumptions are made: 1) The dependent variables are linearly related to the independent variables; 2) The independent variables are not correlated; 3) The error terms are normally distributed; 4) The independent variables and error terms are not correlated; 5) The error terms are not correlated and have a mean zero and constant variance throughout.

Two important statistical problems that were concerns in the analysis are multicollinearity and heteroscedasticity. Multicollinearity is a phenomenon that occurs in a regression model when two or more independent variables tend to move together in the same pattern [23]. When strong multicollinearity exists, the fit of the regression equation usually results in high values of R^2. The presence of a serious multicollinearity problem can be detected by the inspection of the simple correlation among the independent variables. High correlation coefficients are signals suggesting that a problem does exist. However, one should not, a priori, rule out estimation of any regression

equation because of high simple correlation between any two independent variables [39]. Without additional information that would warrant dropping a variable that economic theory suggests should be included in the model, then the variable should not be eliminated. There is no clear cut way to solve the problem of multicollinearity, but a researcher needs to be aware of the possible presence. Instances of multicollinearity worthy of notice due to theoretical or empirical implications will be discussed.

Heteroscedasticity occurs when the assumption of constant variance for the error term is not valid for the data under consideration. The existence of heteroscedasticity may often occur in cross sectional data. The variance of investment and production costs among the larger fire departments, for example, may be greater than the variance among the smaller fire departments [23]. The main effect of heteroscedasticity is on the variance of the coefficient, and not on the bias of the empirical coefficient. This problem can be detected by plotting the residuals against the dependent variable.

Selection of the empirical variables to be used in estimating the parameters of the economic model is made in such a manner as to approximate as closely as possible the theoretical variables specified in the theoretical framework. The selection of variables for a regression equation is always a major problem that relates to data limitations and form of function. Rules are helpful, but they cannot make <u>all</u> of the tough decisions for the applied economist [39]. It is at this point that econometrics becomes more art than science. Friedman comments

from Essays in Positive Economics:

> The capacity to judge that these are or are not to be disregarded, that they should or should not affect what observable phenomena are to be identified with what entities in the model, is something that cannot be taught; it can be learned but only by experience and exposure in the "right" scientific atmosphere, not by rote. It is at this point that the "amateur" is separated from the "professional" in all sciences and that the thin line is drawn which distinguishes the "crackpot" from the "scientist."[7]

The need is to observe how good the predictive and structural qualities of the theoretical model are in empirical estimation so that policy conclusions as well as theoretical advances can be made.

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[7]Milton Friedman, Essays in Positive Economics (Chicago: University of Chicago Press, 1953), p. 25. This strongly worded statement relates back to comments found in Chapter III with regard to the use of the "tools of the trade" in an imaginative but constructive manner.

CHAPTER V

ANALYSIS AND RESULTS

The basic economic model and two modifications of the model were analyzed by using multiple regression techniques. This chapter reports on the methodology used in the analysis and the statistical results of the empirical estimates. Specifically, each estimation is discussed in terms of the explanatory power of the model and the level of significance, behavior, and magnitude of the results displayed by the variables considered.

The Basic Model: The Analysis of Total Cost

The following model of total cost was estimated in the general statistical form of the regression equation specified earlier:[1]

$$E = f(P_1 P_2\ Q\ A\ L\ X_1 X_2 X_3)$$

The exact functional forms of quantitative relationships in econometric studies are rarely completely deduced theoretically. Usually, the final form is determined empirically [Hu, p. 60]. The simplest form is a linear equation. This form is the easiest to estimate and explain, and was assumed to be theoretically correct for the model of total cost. If a model is fitted correctly, the residuals should tend to have no special pattern, but to occur randomly [Hu, p. 64]. The residuals of

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[1] All variables are previously defined in Chapter IV.

this model were plotted against the observed dependent variable, and no special pattern existed.

The coefficient of determination R^2, was .92. This indicates that about 92 percent of the variation in the total cost is explained by the independent variables. The F value of 123.39, significant at the 1 percent level, indicates that the indepent variables acting together in the model provide a high degree of explanatory power. Thus, the model provides a relatively good explanation of the variation in total cost of supplying fire protection services.

The following variables, P_1,Q,A,L,X_2, and X_3, were significant at varying levels of acceptability as shown by the standard t-test (Table 5.1).[2] The dependent variable, total cost, was hypothesized to be positively associated with all the independent variables. All of the independent variables behaved as hypothesized with regard to sign except for the environmental variable measuring the number of manufacturing firms in a community (X_2). A possible reason for this behavior is that a limited number of manufacturing firms in a community represents no real problems for delivering an effective level of fire protection services. In fact, the presence of two or three firsm in a small

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[2]Statistical significance of the regression coefficient is calculated by use of the t-test as follows:

$$t_b = \frac{b}{s_b} \quad \text{where}$$

b = regression coefficient

s_b = the standard error of the regression coefficient

The computed values of t_b are then compared to critical values of the t-distribution contained in F.J. Rohlf and R.R. Sokal, Statistical Tables (San Francisco: W.H. Freeman and Co., 1969), p. 159.

TABLE 5.1

RESULTS OF THE MULTIPLE REGRESSION ANALYSIS
OF THE BASIC MODEL OF TOTAL COST[a]

Total cost - first estimate $R^2 = .922$ $F = 123.39^{***}$

$$E = 149{,}647.77 + \underset{(.9865)}{2.35^{***}P_1} + \underset{(0006)}{.0007^{***}P_2} - \underset{(4401.57)}{11{,}736.75^{***}Q} + \underset{(67.67)}{283.77^{***}A} + \underset{(279.55)}{844.34^{***}L}$$
$$+ \underset{(96.11)}{132.00X_1} - \underset{(536.67)}{938.78^{*}X_2} + \underset{(.08)}{.26^{***}X_3}$$

Total cost - second estimate $F^2 = .921$ $F = 159.48^{***}$

$$E = 143{,}788.14 + \underset{(.8382)}{2.53^{***}P_1} - \underset{(4010.12)}{11{,}513.95^{***}Q} + \underset{(64.49)}{291.44^{***}A} + \underset{(259.13)}{769.41^{***}L}$$
$$+ \underset{(77.29)}{204.43^{*}X_1} - \underset{(499.96)}{915.03^{*}X_2} + \underset{(.06)}{.33^{***}X_3}$$

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[a]Standard error of regression is in parenthesis below the coefficient.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

three firms in a small community may contribute to the more efficient utilization of a fixed resource.

The two insignificant variables in the model were the assessed value of property (P_2) and the population density (X_1). The assessed value of property variable may have been insignificant because these estimates of property value exclude certain types of burnable personal property. As for the population density variable, there may exist diseconomies in sparsely populated rural areas due to distance and in highly concentrated urban areas due to technical problems of delivery. Yet, for the large number of communities in the data base, population density seems to have little influence on total cost.

Further refinement of the choice of independent variables lead to the estimation of an additional model of total cost:

$$E = f(P_1\ Q\ A\ L\ X_1\ X_2\ X_3)$$

The assessed value of property variable (P_2) was dropped without much loss of explanatory power due most likely to high correlation of P_2 with the revenue sharing variable (X_3). (The correlation coefficient (n) was valued at .84.) A possible explanation for this high correlation is that the assessed value of property is caught up in the tax effort coefficient embedded in the revenue sharing allocation process. Tax effort and capacity are closely associated with the assessed value of property in a community.

The resulting R^2 was .92 with an F value of 159.48. This F value was significant at the 1 percent level. All of the variables were

significant at the 5 percent level including the previously insignificant population density variable (X_1). The sign of the environmental variable representing the number of manufacturing firms in a community (X_2) still behaved in a manner opposite of the hypothesis. The signs of the other variables behaved as expected, and the magnitudes of the coefficients were within an acceptable range.

The estimation of the basic model indicates that total cost varies directly with the quantity and quality of fire protection services supplied. The cost of labor is concluded to be the most influential input in regard to total cost. This is shown to be especially true when an imputed value (market equivalent) is assigned to voluntary effort and used as part of the total cost. The correlation between percentage professional and quality level is high ($n = .75$) indicating that increasing the number of professional firemen in a department improves the quality of fire protection delivered. A policy designed to encourage the use of voluntary effort would have a positive effect on limiting and/or maintaining the level of the budget costs of fire protection for a community. The combination of a minimum contingent of professional firemen with a well trained volunteer back-up group seems to be the ideal for optimal quality-cost tradeoffs especially in the smaller communities and rural areas.

Revenue sharing influences total cost indirectly as a ready provider of funds and directly as a proxy for tax effort and tax capacity. This indicates that a community with a high tax effort and a related tax capacity supplies a higher quality of fire protection

services at a higher level of total cost.

The physical environmental variables did not affect total cost greatly. It is concluded that the relatively homogeneous environment of the communities in the study resulted in this lack of influence. Most likely, the physical setting in which fire protection services are supplied would become exponentially important in the larger cities with high density housing and manufacturing and multistories buildings.

A Modification of the Basic Model: The Analysis of Average Cost

To progress further in the explanation of the cost of supplying fire protection services, the basic total cost model was modified in a way that yielded an appropriate average cost model. Average cost is traditionally defined as the cost per unit of output (total cost divided by the quantity produced). Obviously, one needs to be able to define the units of output and determine the quantity produced. For a public service this can be a difficult task. In the case of fire protection, output may be measured in terms of the size of the population protected. Cost per unit of output therefore becomes the cost per unit of population protected.

Two hypotheses are suggested with regard to the shape of the average cost function for fire protection services. They are:

1) The true shape of the average cost function is hypothesized to be L-shaped;
2) The L-shaped cost curve cannot be approximated empirically unless all costs are included.

The main reason for expecting an L-shaped curve is that fire departments which protect the larger populations maintain manpower levels for a higher than average level of utilization. This is due to the unique labor input that becomes a fixed cost. As the largest factor in total cost, the labor input is a more important cost factor over time than the capital assets of equipment and buildings. The cost for items such as gasoline, oil, maintenance, and depreciation, however, are variable and depend upon the amount of actual output in the form of alarms responded to over time. Moreover, nothing over the range of data suggested an upward bending of the average cost function because of increases in population levels protected.

To test these hypotheses, the average cost curve was plotted using population protected as the unit of output. The first plot excluded the inputed value for voluntary effort and resulted in a random distribution of observation points. The second plot was of a more comprehensive average cost estimate that included the inputed value for voluntary effort. This resulted in a relatively smooth L-shaped average cost curve (Figure 5.1).

The following model of average cost was estimated in an attempt to fit the L-shaped form as hypothesized above:

$$\frac{E}{P_1} = f\left[\frac{1}{(P_1)}\ 2,\ L\right]$$

The variables in this model are defined the same as the variables in the total cost model. The estimated regression equation resulted in a R^2 of

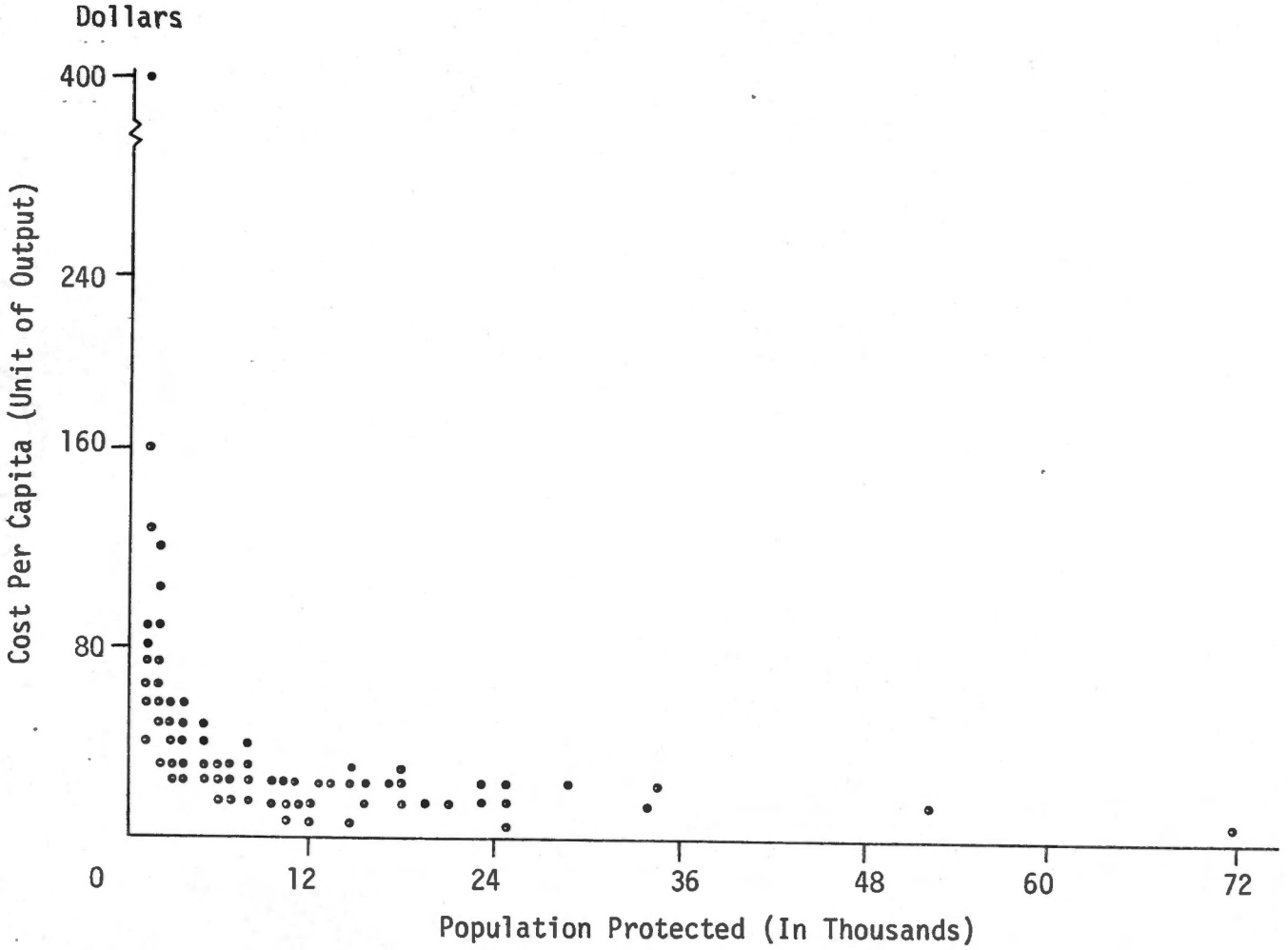

Figure 5.1. Average cost per capita of fire protection services based on population protected.

.64, and an F value of 93.31 which was significant at the 1 percent level. Each of the independent variables was significant at the 1 percent level. Plotting this regression equation resulted in a smooth and continuous L-shaped average cost curve which indicates the presence of economies of scale.

The L-shaped average cost function can be used to measure these economies of scale for supplying fire protection services. The estimate of the cost per unit of population protected curve shows that at about 2,000 population protected, the cost per unit of output begins to decrease at an increasing rate until it levels off at about 12,000 population protected. The decrease in per unit cost indicates the range over which the cost of labor becomes a large proportion of total cost. Quite possibly, communities located in close proximity to each other may be able to realize a reduction in public total cost by consolidating their fire protection efforts.

A Modification of the Basic Model: The Analysis of Marginal Cost and Supply

A single fire department located in a single community or geographic area outwardly appears to represent a situation with monopolistic elements. The fire department represents a single supplier enjoying the absence of competition and with complete control of the product, in this case fire protection. However, it is soon realized that this monopoly position is based upon location and area rather than upon economic power. Assuming that people and industry are mobile enough to demand and satisfy specific locational preferences, the

situation then begins to exhibit a more competitive nature.[3] Communities are thus seen to compete for industry and population with the public service mix that is offered at varying levels of cost. For example, management desirous of locating an industry in a community with a high quality level of fire protection services would choose (demand) the community which supplied the highest quality of fire protection services (product) at the lowest cost (tax structure) in the geographic area (market) in which they wish to locate. With all other locational considerations such as work force skill levels equal, these locational decisions are considered to be competitive. In a competitive economic situation, the supply curve of an individual firm (in this case a fire department) may be defined as the part of the marginal cost curve which lies in the relevant range of cost prescribed by rational economic behavior. Therefore, by delineating the marginal cost for fire protection services supplied, one arrives at an approximation of the supply curve for fire protection services at the department (firm) level.

To accomplish this objective in an economically meaningful way, several assumptions must be made to relate the economic theory of the firm to the analysis of a public service. The assumptions are:
1) Marginal cost is an optimality concept that can be used only when some rational maximization is pursued on the part of decision makers [17]. The assumption is thus made that local decision-makers attempt to

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[3]The "voting with one's feet" argument is adopted in part from Charles Tiebout's classical article "A Pure Theory of Local Expenditures," Journal of Political Economy, Vol, LXIV, No. 5, October, 1956 [56].

maximize the level of the public service mix available to a community subject to governmental budget constraints; 2) Constant input costs are assumed for the aggregate, in the sense that expanded resource use does not entail an increase in resource prices; 3) The marginal cost of a public service is assumed to be equal to the slope of total cost as varying levels of output quality.

In this analysis of marginal cost and supply, extensive use is made of qualitative independent variables (dummy variables). These dummy variables were entered into a regression equation so that an estimate of the slope of the total cost function at varying levels of output quality could be determined.

Slope is defined as the limit of the ratio of change in cost to the change in output produced when the change in output produced approaches zero. One observes from this definition that the concept of the slope of a curve is the geometric counterpart of the concept of a derivative. The coefficients of a regression equation are partial derivatives of the total function. Thus, the regression coefficient of each of the dummy variables represents the slope of total cost or the value of marginal cost at the respective level of quality represented by that particular dummy variable. The dummy variables were used in additive form to allow for differential intercepts for the quality of output variables so that their relationship to the dependent variable at different levels of quality can be observed.[4] The output quality

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[4]J. Johnson, Econometric Methods, 2nd Edition (New York: McGraw-Hill Book Company, 1972), and P. Rao and R.L. Miller, Applied Econometrics (Belmont, Cal.: Wadsworth Publishing Company, Inc., 1971). Both

variables are organized in terms of ascending order to magnitude. By definition each ISO grade level is represented by a discrete number (1-10). Each of these quality levels of ISO grades is represented by a dummy variable, with the exception of ISO grade 10 which is treated as the required "excluded" category. The estimation of distinct values for marginal cost show the amount of revenue needed at the margin should a policy of improved quality be under consideration.

The generalized dummy variable model used in the analysis is as follows:

$$E = a + b_1 D_9 + b_2 D_8 + b_3 D_7 + b_4 D_6 + b_5 D_5 + b_6 D_4$$

where E equals total cost, a is the "cost" intercept, the b's are the regression coefficients, and the D's are the dummy variables representing the quality level (ISO grade) indicated by the subscripts. The omitted quality level is ISO grade 10 which represents the lowest quality of performance for a fire department. (This quality level is analyzed by looking at the intercept value.)

The estimated model resulted in an R^2 of .77. The F value was 55.79 which was at a significant level of 1 percent. All of the coefficients are significant at the 1 percent level with the exception of D_8 and D_7. This indicates that the intercept differences are not significant between these quality levels. The values of marginal cost of each of the quality levels are represented by the respective regression

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of these books contributed significantly to the understanding of this particular use of the dummy variable concept.

coefficients (Table 5.2). By observing the values assigned to marginal cost, one knows how much the public cost is for moving from one quality level to another quality level of fire protection services. By plotting these values, a marginal cost curve can be delineated for varying levels of output quality (Figure 5.2). With the assumptions made, this graph of marginal cost represents an approximation of the supply curve for fire protection services at the department (firm) level.

The suggestion is made that an exogenous influence on the political process which causes a decrease in risk and uncertainty for local decision makers in turn would cause the supply curve for a public service, such as fire protection, to become more elastic or responsive. Revenue sharing is an exogenous influence that meets this criteria. The unattached funds from the revenue sharing program can be spent for public purposes without political risk at the local level. To illustrate this increase in the elasticity of supply, the following model is estimated using the methodology described above:

$$E = a + b_1 D_9 + b_2 D_8 + \ldots + b_6 D_4 + b_7 X_3$$

All dummy variables are defined as above, and the X_3 variable represents the exogenous influence of revenue sharing.

The estimated model resulted in an R^2 of .86. The F value is 90.66 which is at a significance level of 1 percent. All of the coefficients including the new X_3 variable are significant at the 1 percent level with the exception again of D_8 and D_7 (Table 5.2). By plotting the regression coefficients of the dummy variables, a supply

TABLE 5.2

RESULTS OF THE MULTIPLE REGRESSION ANALYSIS
OF THE MODEL OF MARGINAL COST[a]

Marginal Cost - first estimate[b] $R^2 = .77$ $F = 55.79^{***}$

$$E = 76{,}461^{***} + 20{,}989D_9 + 8{,}053D_8 + 73{,}839D_7^{***} + 180{,}054D_6^{***} + 485{,}910D_5^{***} + 518{,}902D_4^{***}$$

(36,446) (18,052) (19,825) (19,216) (33,036) (69,876)

Marginal Cost - second estimate[c] $R^2 = .86$ $F = 90.66^{***}$

$$E = 60{,}895^{***} + 16{,}898D_9 + 2{,}937D_8 + 41{,}112D_7^{***} + 78{,}671D_6^{***} + 183{,}382D_5^{***} + 364{,}278D_4^{***} + .59X_3$$

(28,086) (13,922) (15,762) (19,089) (44,051) (56,890) (.07)

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[a]Standard error of regression is in parenthesis below the coefficient.

[b]Estimate without the revenue sharing variable.

[c]Estimate with the revenue sharing variable.

***Significant at the 1 percent level.

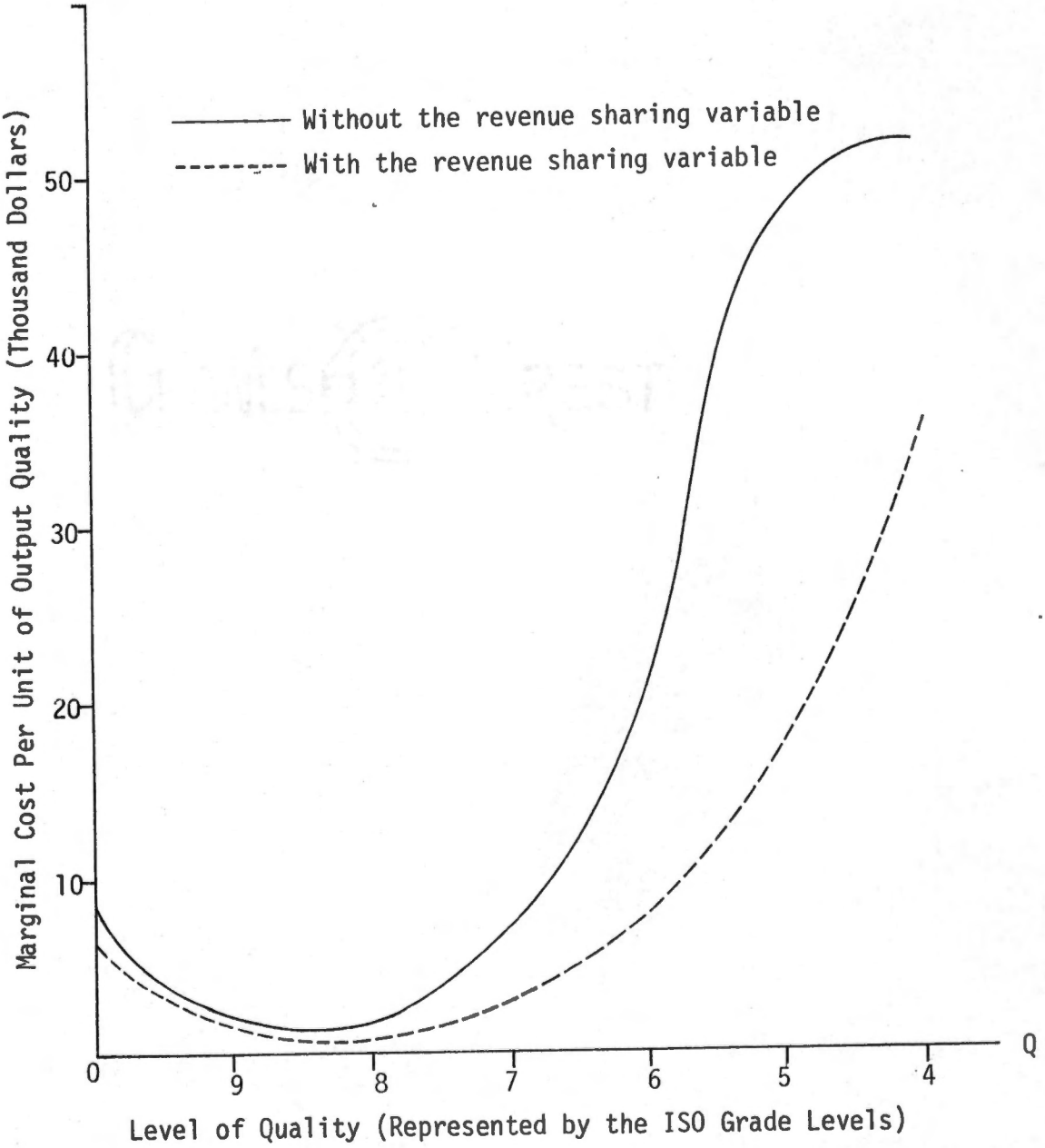

Figure 5.2. Marginal cost values at varying levels of output quality with and without the revenue sharing variable.

curve is approximated that is indeed more elastic than the previously estimated supply curve (Figure 5.2).

The dummy variables are shown to have intercepts significantly different from one another if the coefficients are shown to be significant by the standard t-test. When a coefficient is found to be insignificant, this indicates that the marginal difference in cost between the insignificant ISO grade coefficient and the next lower and higher ISO grade coefficients is insignificant enough to be indifferentiable in magnitude. This implies that the marginal cost of improving the quality of fire protection services supplied is at these specific ISO grade levels negligible.

Two of the variables in the model representing ISO grades 9 and 8 (D_9 and D_8) are insignificant, therefore a more thorough examination of the results of the regression is necessary. The move from an ISO grade 10 rating to an ISO grade 9 rating by a community does not require any major capital investments. Therefore, it is concluded that the insignificance of the coefficient is justified, and the marginal cost of moving from ISO grade 10 to ISO grade 9 is negligible. However, the insignificant cost difference between ISO grade 9 and ISO grade 8 is not justified. Most likely it is due to the exclusion of the cost of an adequate community water system from the model. This is a major capital investment, and the most important additional requirement differences between ISO grade 9 and ISO grade 8. Thus the actual differences between the two ISO grades with respect to cost is decidely more significant than indicated by the regression results.

The influence of revenue sharing upon the elasticity of supply suggests even wider ranging impacts. It is concluded that a decrease in the risk and uncertainty for local decision makers would make the supply function of public service, such as fire protection, more responsive. The improvement of the level of public services in a community improves the quality of life for the citizens, but more importantly, this improvement may provide the needed emphasis for a sustained period of economic development. As shown in previous research, employment providing industries are attracted to communities with good public services, and in particular, a high level of fire protection service [10, 53].

CHAPTER VI

SUMMARY OF FINDINGS AND SUGGESTIONS FOR FUTURE RESEARCH

The overall purpose of this study was to gain a fuller understanding of the public costs of supplying fire protection services to the small communities and rural areas of Tennessee. The primary objectives were to discuss the theoretical viewpoints relevant to the economic analysis of the cost and supply of a public service; to examine the setting in which fire protection is delivered; and to examine the total and average cost of supplying fire protection services; and to delineate a supply function for fire protection services. The problem is one of improving the quality and quantity of the fire protection services supplied to communities in the face of generally unfavorable financial conditions. Improvement of this vital service should help promote community development and improve the quality of life for people in the smaller communities and rural areas of Tennessee. This chapter contains a summary of the findings of the study and suggestions for the direction of future research efforts in public service analysis.

Summary of Findings

The fire chiefs of departments serving rural municipalities and communities were surveyed to provide general information on the setting in which the delivery of fire protection services takes place. Information from the fire chiefs was obtained on the Insurance Services Office (ISO) evaluation system and other indicators of quality performance, the

political climate at the local level, and the use of revenue sharing funds for fire protection.

Fifty-eight percent of the fire chiefs responding felt that the grade assigned to fire protection services for their communities by the ISO was a true reflection of the fire prevention and fire suppression capabilities of the fire departments under their jurisdiction. However, 75 percent of those responding indicated that improvement of the ISO grading system was necessary. Specific suggestions for improvement were as follows: 1) A need to consider more adequately the differences between rural and urban fire protection requirements relative to equipment, water supply, and manpower; 2) A need to consider more fully fire prevention efforts of a fire department, and a necessity for providing incentives for this activity; 3) A need to evaluate the effectiveness of volunteer firemen at a more equivalent ratio with professional firemen recognizing the training, performance, and firefighting experience of today's volunteer fireman; 4) A need on the part of the fire chiefs for more open and informative communications from the ISO about evaluation procedures, policies, and actual evaluations of fire departments in individual communities; and 5) A need to develop and use better indicators of quality performance for evaluation purposes such as response time and fire suppression effectiveness.

The fire chiefs also felt that more frequent fire department evaluations would be helpful, that the ISO grading system should be made more uniform statewide, and that eventually national standards should be set for this evaluation process.

Questions were asked of the fire chiefs to help assess the dynamic and static aspects of the political process in which policy decisions that affect the quantity and quality of fire protection services were made. In general, local officials cooperate with the fire chiefs to plan for and budget fire protection services in the community. However, elected county officials do not seem to respond adequately to the need for expanded fire protection in the outlying rural areas of the counties. Public support for improved fire protection services in general is at a high level, but this public support weakens slightly for the all professional staffed departments and for the small communities where the felt need for fire protection services may not be as intense as in the larger communities.

The availability of revenue sharing funds for communities in Tennessee has made an impact on fire protection services in the state. Fifty-seven percent of the fire chiefs surveyed indicated that revenue sharing funds have been used for fire protection purposes. The data showed that 1 1/2 percent of the total amount of revenue sharing funds received by Tennessee communities from the initial entitlement through the Fifth Entitlement Period (1972 through fiscal year 1974-75) was used for fire protection.

Of the actual dollars spent, the most frequent investment was for new equipment. The level of these investments ranged from $150 to $68,182 per fiscal year for a single fire department. Total dollars of revenue sharing funds spent on new equipment was $1,030,520 from the first entitlement period (1972) through fiscal year 1974-75 for the 59

departments that reported spending funds for this purpose. The most popular choices for investment were the large ticket items, mainly pumper and tanker trucks, many priced between $40,000 and $55,000.

Ten fire departments used the additional revenue for their communities to offset the ever increasing cost of labor. These expenditures during the three year period under consideration ranged between $420 and $250,190 per fire department. Total revenue sharing funds spent on labor for this three fiscal year period (1972-75) was $719,895. Eight fire departments during this same three year period used this opportunity to use revenue sharing funds to improve old or to build new structures. Of these eight departments, only three made a substantial investment of $25,000 or more. The total amount spent was $181,015.

The analysis of total costs showed that the cost of supplying fire protection services was dependent more upon the quantity of output supplied, the quality of output produced, the number of alarms, and the number of professional firemen than upon the environment in which this public service was delivered. Total cost varied directly with the quantity and quality of fire protection services supplied. The cost of labor was concluded to be the most influential input in regard to total cost. This was shown to be especially true when an imputed value (market equivalent) was assigned to voluntary effort and used as part of the total cost. Increasing the number of professional firemen in a department improved the quality of fire protection delivered. A policy designed to encourage the use of voluntary effort would have a positive effect on limiting and/or maintaining the level of the budget costs of

fire protection for a community. The combination of a minimum contingent of professional firemen with a well trained volunteer back-up group seemed to be the ideal choice for optimal quality-cost tradeoffs especially in the smaller communities and rural areas.

Revenue sharing influences the quantity and quality of fire protection services directly as a ready provider of funds and indirectly as a proxy for tax effort and tax capacity. A community with a high tax effort and a related tax capacity supplies a higher quality of fire protection services at a higher level of total cost.

The physical environmental variables were concluded not to affect total cost greatly. The relatively homogeneous environment of the communities in the study resulted in this lack of influence. Most likely, the physical setting in which fire protection services are supplied would become exponentially important in the larger cities with high density housing and manufacturing and multistoried buildings.

As for population density, there may exist diseconomies in sparsely populated rural areas due to distance and in highly concentrated urban areas due to technical problems of delivery. Yet, for the larger number of communities in the data base, population density seemed to have little influence on total cost. It seemed also that a limited number of manufacturing firms in a community represents no real problems for delivering fire protection services. In fact, the presence of two or three firms in a small community may contribute to the more efficient utilization of the fixed resource that the capital and large labor investment in fire protection represents.

The L-shaped average cost function can be used to measure the magnitude of economies of scale for supplying fire protection services. This curve, or the estimate of the cost per unit of population protected curve, showed that from about 2,000 population protected, economies of scale were encountered to a level of 12,000 population where the cost per unit of output leveled off. This indicates the point where the cost of labor becomes a large proportion of total cost. Quite possibly, communities located in close proximity to each other may be able to realize a reduction in public total cost by consolidating their fire protection efforts.

The present study illustrates the use of a theoretical and analytical framework that might be applied to other public services. The need is for research on specific public services designed to provide solutions to problems of public policy. Improved measures of output in terms of both quantity and quality are needed. Models of cost and supply for each public service need further development. The use of simultaneous systems of equations, time series data, and a deeper look at functional form would be of value in obtaining useful research results. Linear programming might be utilized to provide budgeting analysis for specific public services at the firm and/or aggregate levels. Optimal budgeting solutions could be obtained subject to the appropriate constraints at the firm level. At the aggregate level a "representative" unit of production approach could be used to generate aggregate demand and supply functions.

The economics of voluntary effort has been ignored, in most cases, in previous research dealing with public services. With an actual and potential economic impact of considerable magnitude on the cost and supply of public services at the local level, it is critical that a more thorough consideration of the economics of voluntary effort be made. Information of the opportunity cost and effectiveness of voluntary effort could be utilized to minimize the total public cost of delivering an optimal mix of public services to a community.

Revenue sharing was found to be highly influential on the cost and supply of fire protection services. The utilization and distributional aspects of the revenue sharing funds are a fruitful area of inquiry. More complex measures of fiscal effort and capacity would be required to understand more fully the impact of revenue sharing upon the level of public services supplied. Revenue sharing, implicitly and explicitly, is a topic on the frontiers of these measurement problems.

Suggestions for Future Research

Future research can be directed toward expansion and refinement of the present study, and toward further investigation of tangential topics. In all cases, the theoretical and empirical work should move in complementary directions for the continued advancement of theory and the improved effectiveness of public policy decision making. The goal is the improvement of the quality of life for all.

LIST OF REFERENCES

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[1] Adams, Robert F. "On the Variation in the Consumption of Public Service," The Review of Economics and Statistics, XLVII, No. 4, November 1965.

[2] Arrow, Kenneth. Social Choice and Individual Values, Sec. Ed. Wiley, New York, 1963.

[3] Badenhop, M.B. and T.M. Jones. "Fire Protection Service for Rural Areas and Fire Insurance Coverage of Rural Properties in Tennessee," Tennessee Farm and Home Science Progress Report 92, October-November-December, 1974, University of Tennessee, Knoxville.

[4] Birdsall, William C. "A Study of the Demand for Public Goods," Essays in Fiscal Federalism, Richard A. Musgrave, ed., The Brookings Institution, Washington, D.C., 1965.

[5] Bradford, D.F., R.A. Malt, and W.E. Oates. "The Rising Cost of Local Government Services: Some Evidence and Reflections," National Tax Journal, Vol. XXII, No. 2, June 1969.

[6] Brunn, R. Beto. "Public Service Lends in Rural Communities: Additional Conceptual Considerations," paper presented at the Rural Sociological Section, SAAS Meetings, New Orleans, February 1975.

[7] Buchanan, James M. and Gordon Tullock. The Calculus of Consent, University of Michigan Press, Ann Arbor, 1962.

[8] Chase, S.B. "Introduction and Summary," Problems in Public Expenditure Analysis, The Brookings Institute, Washington, D.C., 1966.

[9] Davis, Otto A. "Empirical Evidence of Political Influences Upon the Expenditure Policies of Public Schools," in The Public Economy of Urban Communities, Julius Margolis, ed., Resources for the Future, Washington, D.C., 1965.

[10] Deaton, B.J. and D.L. Gunter. "The Influence of Community Characteristics on Industrial Plant Location and Expansion: A Preliminary View," Tennessee Farm and Home Science Progress Report 91, July-August-September, 1974.

[11] Department of Treasury, Office of Revenue Sharing, Data Elements for Entitlement Period 5, Washington, D.C., October 1974.

[12] de Tocqueville, Alexis. Democracy in America, Vol. II, Schocken Books, New York, 1961.

[13] Ferguson, C.E. Microeconomic Theory, Richard D. Irwin, Inc., Homewood, Illinois, 1972.

[14] Friedman, Milton. Essays in Positive Economics, University of Chicago Press, Chicago, 1953.

[15] Friedman, Milton. Price Theory, A Provisional Text, Aldine Publishing Co., Chicago, 1962.

[16] Fyffe, David E. and Ronald L. Rardin. An Evaluation of Policy Related Research in Fire Protection Service Management, under NSF Grant GI-39064, Georgia Institute of Technology, Atlanta, Georgia, October 1974.

[17] Hirsch, Werner Z. The Economics of State and Local Government, McGraw-Hill Book Company, New York, 1970.

[18] Hirsch, Werner Z. "The Supply of Urban Public Services," Issues in Urban Economics, Harvey S. Perloff and Lowdon Wingo, eds. Johns Hopkins Press, Baltimore, 1968.

[19] Hitzhusen, Fred J., "Federal Revenue Sharing: Some Implications for Rural Communities," unpublished paper, Ohio State University, Columbus, Ohio, 1974.

[20] Hitzhusen, Frederick J. "Public-Private Fire Protection Cost Trade-Offs in Texas and New York: A Benefit-Cost Analysis," A.E. Res. 73-9, Department of Agricultural Economics, Cornell University, Ithaca, New York, May 1973.

[21] Hitzhusen, Frederick J. "Some Measurement Criteria for Community Service Output and Costs: The Case of Fire Protection in Texas," Southern Journal of Agricultural Economics, Vol. 5, No. 1, July 1973.

[22] Hitzhusen, Frederick J. "Some Policy Implications for Improved Measurement of Local Government Service Output and Costs: The Case of Fire Protection," unpublished Ph.D. Dissertation, Cornell University, 1972.

[23] Hu, Teh-wei, Econometrics, An Introductory Analysis, University Park Press, Baltimore, 1973.

[24] Hyman, David N., The Economics of Governmental Activity, Holt, Rinehart, and Winston, Inc., New York, 1973.

[25] Insurance Services Office, "Specifications for Rural Fire Departments: General," Nashville, Tennessee, January 1973.

[26] Johnson, J. Econometric Methods, Second Edition, McGraw-Hill Book Company, New York, 1972.

[27] Jones, Lonnie L. and Paul H. Gessaman. "Public Service Delivery in Rural Areas: Problems and Decisions," unpublished paper, undated.

[28] Kane, Edward J. Economic Statistics and Econometrics, Harper and Row, Inc., New York, 1968.

[29] Lee, Alvin T.M. "Texas and Financing of Public Services," Agricultural Review, CSRS, USDA, Vol. 10, No. 1, First Quarter, 1972.

[30] Margolis, Julius. "The Demand for Urban Public Services," Issues in Urban Economics, Harvey S. Perloff and Lowdon Wingo, eds., Johns Hopkins Press, Baltimore, 1968.

[31] McKean, R.N. "The Use of Shadow Prices," Problems in Public Expenditure Analysis, Samuel B. Chase (ed.), The Brookings Institute, Washington, D.C., 1966.

[32] Musgrave, Richard A. "Comments on Part III," Issues in Urban Economics, Harvey S. Perloff and Lowdon Wingo, eds., Johns Hopkins Press, Baltimore, 1968.

[33] Nathan, Richard P., Allen D. Manvel and Susannah E. Calkins. Monitoring Revenue Sharing, The Brookings Institution, Washington, D.C., 1975.

[34] National League of Cities, The Grading of Municipal Fire Protection Facilities: Its Relationship to Fire Insurance and to the Municipality's Fire Protection Policy, Washington, D.C., July 1967.

[35] Pickett, J.C. "Optimal Quantity of Fire Department Services," unpublished Ph.D. Dissertation, University of Missouri, 1970.

[36] Pidot, George B. "A Principal Components Analysis of the Determinants of Local Government Fiscal Patterns," The Review of Economics and Statistics, LI, No. 2, May 1967.

[37] Public Technology, Inc., "New Provisions of the ISO Grading Schedule," Washington, D.C., March 1974.

[38] Quindry, Kenneth E., "The Critical Problem of Local Government Revenue," Tennessee Survey of Business, May 1970.

[39] Rao, Potluri, and Roger L. Miller, Applied Econometrics, Wadsworth Publishing Company, Inc., Belmont, California, 1971.

[40] Reddy, R.D. and D.H. Smith, "Who Participates in Voluntary Action," Journal of Extension, Fall 1973.

[41] Reddy, R.D. and D.H. Smith, "Why Do People Participate in Voluntary Action," Journal of Extension, Winter 1974.

[42] Ridley, Clarence E. and Herbert A. Simon, Measuring Municipal Activities, The International City Managers Association, Chicago, Illinois, 1943.

[43] Rohlf, F. James, and R.R. Sookal, Statistical Tables, W.H. Freeman and Company, San Francisco, 1969.

[44] Samuelson, Paul A., "Aspects of Public Expenditure Theories," Review of Economics and Statistics, Vol. 40, No. 4, November 1958.

[45] Schaeniman, Philip S. and Joe Swartz, Measuring Fire Protection Productivity in Local Government, National Fire Protection Association, Boston, 1974.

[46] Senice, Jolayne, A User's Guide to the Statistical Analysis System, Student Supply Stores, North Carolina State University, Raleigh, August 1972.

[47] Sirageldin, Ismail A., Non Market Components of National Income, Survey Research Center, University of Michigan, Ann Arbor, 1969.

[48] Stenzel, Anne K. and Helen M. Feeney, Volunteer Training and Development, The Seabury Press, New York, 1968.

[49] Stinson, Thomas F. and Jerome M. Stam, "Voluntary Labor and Non Metropolitan Government: Some Initial Considerations," a paper delivered to the Annual Meeting of the American Agricultural Economics Association, August 18-21, 1974, College Station, Texas.

[50] Tax Foundation, Inc., The Financial Outlook for State and Local Government to 1980, Research Publication No. 28 (New Series), Tax Foundation, Inc., New York, 1972.

[51] Tennessee Department of Economic and Community Development, 1975 Directory of Manufacturers, Nashville, 1975.

[52] Tennessee Taxpayers Association, The 1972 Annual Survey of County, City, and Town Government in Tennessee, Research Report No. 187, Nashville, 1973.

[53] The University of Tennessee, Center for Business and Economic Research, Tennessee Statistical Abstract 1974, Knoxville, Tennessee, April 1974.

[54] Tiebout, Charles M., "A Pure Theory of Local Expenditures," Journal of Political Economy, Vol. LXIV, No. 5, October 1956.

[55] U.S. Department of Commerce. "Survey of Industrial Location Determinants 1921-1975," Economic Development Administration, February 1973.

[56] Will, Robert E. "Scalar Economics and Urban Service requirements," Yale Economic Essays, No. 5, Spring 1965.

APPENDIXES

APPENDIX A

SURVEY OF FIRE CHIEFS

Name_____

Fire Department_____ City ☐ County ☐

1. In total, how many full-time paid professional firemen (please include yourself if appropriate) are there in your fire department?_____ Of the professional firemen, how many are officers?_____

2. How many fully active volunteer firemen are there in your department?_____

3. How many alarms that are directly related to fire suppression are answered by your department on the average during a one-year period?_____

4. On the average, how many volunteer firemen respond to an alarm?
_____

5. Is there compensation of any sort for the volunteer firemen?

   Yes ☐ No ☐

   If yes, how much? $_____ per ☐ year ☐ month ☐ Alarm (Check One)

6. How many people are protected by your department?_____ Is this number influenced by any special considerations such as a large influx of tourists at certain times of the year? ☐ Yes ☐ No

7. What type of alarm system does your fire department use?
   ☐ Telephone ☐ Siren ☐ Pocket Pager

8. What is the total budget for your fire department in 1972-73?
   $_____ 1973-74? $_____ 1974-75? $_____

   How much of this was used to cover equipment maintenance in 1972-73?
   $_____ 1973-74? $_____ 1974-75? $_____

   How much of this was to cover labor costs in 1972-73? $_____
   1973-74? $_____ 1974-75? $_____

   How much was used to purchase new fire fighting equipment in
   1972-73? $_____ 1973-74? $_____
   1974-75? $_____

9. Do the local community decision-makers cooperate with fire service officials on matters concerning fire protection such as planning for water systems, purchases of fire fighting equipment, and the total department budget? ☐ Yes ☐ No

10. Do the elected county officials actively support improved fire protection services for the rural areas of the county? ☐ Yes ☐ No

11. Do the citizens of your community actively support improved fire protection services for your community? ☐ Yes ☐ No

12. Does the Insurance Services Office (ISO) rating as indicated by the insurance grade level of your community reflect the true fire prevention and fire suppression capabilities of your fire department? ☐ Yes ☐ No

13. Could the ISO rating system be improved? ☐ Yes ☐ No If yes, what suggestion would you have to make an improvement?_____

_____

_____

14. Rank the following from 1 (best) to 5 (worst) as to which is the best indicator of quality performance for a fire department.

☐ Response time (first report to arrival on scene)

☐ ISO rating system grade number

☐ Population protected per dollar of fire department expenditures

☐ Number of professional firemen in department

☐ Fire suppression effectiveness (damage spread after department arrival)

15. What is the base salary of the regular professional firemen in your department on an annual basis? A range of from $_____ to $_____.

16. Are there any private fire departments in your community? ☐ Yes ☐ No If yes, does your department cooperate with them? ☐ Yes ☐ No

17. Since your community began receiving Federal General Revenue Sharing funds, was any of this money used to purchase fire fighting equipment? ☐ Yes ☐ No For the construction of new fire department structures? ☐ Yes ☐ No To add more professional firemen? ☐ Yes ☐ No If so, please indicate how much was spent in each of the following years:

	Equipment	Structures	Labor
In the year 1972-73	$	$	$
In the year 1973-74	$	$	$
In the year 1974-75	$	$	$
Projected for the year 1975-76	$	$	$

18. Are there areas in your county without any fire protection at all?
☐ Yes ☐ No

19. As a fire chief, are you interested in the information of a "Fire Fighters" association to represent the firemen of Tennessee?
☐ Yes ☐ No

20. What type of equipment is in use by your fire department?

	Truck Type	Make		Model	Year Purchased	Pump Capacity	Water Carried
		Chassis	Pumper				
(1)							
(2)							
(3)							
(4)							
(5)							
(6)							
(7)							

THE END.

THANK YOU FOR YOUR COOPERATION. THE ANSWERS YOU HAVE GIVEN, ALONG WITH THOSE OF OTHER FIRE CHIEFS IN THE STATE, WILL BE USED TO FIND MORE EFFICIENT WAYS TO DELIVER FIRE PROTECTION SERVICES TO ALL THE PEOPLE OF TENNESSEE.

*****THE QUICK RETURN OF YOUR ANSWERED QUESTIONNAIRE WILL BE APPRECIATED*****

APPENDIX B

TABLE B-1

THE INSURANCE SERVICES OFFICE GRADING FEATURES BY RELATIVE VALUES AND MAXIMUM DEFICIENCY POINTS

Feature	Percent	Points
Water supply	39	1,950
Fire department	39	1,950
Fire service communications	9	450
Fire safety control	13	650
Total	100	5,000

Source: Insurance Services Office, Grading Schedule for Municipal Fire Protection (New York: Insurance Services Office, Municipal Survey Service, 1973), p. 2.

TABLE B-2

ITEMS CONSIDERED IN THE GRADING SCHEDULE FOR MUNICIPAL FIRE PROTECTION

Grading feature and item number	Description
Water supply	
1	Adequacy of supply works
2	Reliability of source of supply
3	Reliability of pumping capacity
4	Reliability of power supply
5	Condition, arrangement, operation, and reliability of system components
6	Adequacy of mains
7	Reliability of mains
8	Installation of mains
9	Arrangement of distribution system
10	Additional factors and conditions relating to supply and distribution
11	Distribution and hydrants
12	Hydrants - size, type and installation
13	Hydrants - inspection and condition
14	Other conditions adversely affecting adequacy, reliability, or operation of the system
Fire department	
1	Pumpers
2	Ladder trucks
3	Distribution of companies and types of apparatus
4	Pumper capacity
5	Design, maintenance, and condition of apparatus
6	Number of officers
7	Department manning
8	Engine and ladder company unit manning
9	Master and special steam devices
10	Equipment for pumpers and ladder trucks
11	Hose
12	Condition of hose
13	Training
14	Response to alarms
15	Fire operations

TABLE B-2 (continued)

Grading feature and item number	Description
16	Special protection
17	Other conditions adversely affecting operations
Fire service communications	
1	Communication center
2	Communication center equipment and current supply
3	Boxes
4	Alarm circuits and alarm facilities including current supply at fire stations
5	Material, construction, condition, and protection of circuits
6	Radio
7	Fire department telephone service
8	Fire alarm operators
9	Conditions adversely affecting use and operation of communications facilities and the handling of alarms
10	Credit for boxes installed in residential districts
Fire safety control	
1	Flammable or compressed gases
2	Flammable or combustible liquids
3	Special hazards
4	Miscellaneous hazards
5	Supplemental fire prevention activities
6	Building laws
7	Electricity
8	Heating and ventilating installations
Additional deficiencies	
1	Adverse climatic conditions
2	Other adverse conditions or occurrences
3	Divergence between water supply and fire department

Source: Insurance Services Office, Grading Schedule for Municipal Fire Protection (New York: Insurance Services Office, Municipal Survey Service, 1973), pp. 6-7.

APPENDIX C

INSURANCE SERVICES OFFICE EVALUATION SYSTEM

During the first decade of this century, the capital stock fire insurance companies became concerned with the recurrence of major fires in American cities. Believing that the conditions which are conducive to large disastrous fires can be recognized and corrected, the National Board of Fire Underwriters (NBFU), which was the service organization of that group, made a detailed study of fire hazards and fire protection in many of the large U.S. cities. Since the study revealed that factors responsible for major fires could be identified and corrected, the Engineering Department of the NBFU was created.

The Engineering Department of the NBFU developed a set of standards which would provide an equitable basis for appraising cities from the standpoint of their fire protection facilities and fire loss possibilities. This led to the development of the "Standard Schedule for Grading Cities and Towns with Reference to Their Fire Defenses and Physical Conditions" in 1916. Five new editions of the Standard Schedule have been issued since that time. The present schedule is called the "Grading Schedule for Municipal Fire Protection." These standards were arrived at by the application of engineering principles and a study of performance records and pertinent conditions over an extended period of time. In time, a set of numerical classifications was constructed to indicate the degrees of fire protection.

At first the insurance companies used the Grading Schedule as a means of evaluating the risk of insuring a given property. However, some years later the fire insurance rating bureaus used the classification resulting from the application of the Grading Schedule as a measure of fire protection and hence as one of the factors considered in making fire insurance rates. In theory the numerical classification allowed a city with better public fire protection to have lower fire insurance rates.

The American Insurance Association (formerly the National Board of Fire Underwriters) determines the strength of the fire defenses of all cities over 25,000 in population. In Tennessee, the Insurance Services Office (ISO) surveys communities whose population is less than 25,000.

The Insurance Services Office (ISO), which has its main office in Nashville, is a private, nonprofit organization maintained at the state level and is supported on a subscription basis by most of the fire insurance companies doing business within the state. The ISO is subject to regulation by the Tennessee Department of Insurance. In addition to grading communities on their fire defenses, a principal function of the ISO is to establish fire insurance rates under the regulation of state laws.

In both instances the Grading Schedule is used to measure the relative value of a community's fire defenses. The primary responsibility of the ISO is "to establish fire insurance and related rates that are fair, reasonable, and adequate for the safety of the insurer." These

rates should not "unfairly discriminate between risks in the state involving essentially the same hazards or between risks in the application of like charges and credits." In order to establish rates which are reasonable, adequate, and not unfairly discriminatory, the ISO must find a beginning point or base by establishing the fire protection class of a community. This is done by applying the Grading Schedule to the fire defenses and physical conditions of a community.

The Grading Schedule has four broad categories used for grading and rate-making purposes. These categories include water supply, fire department, fire service communications, and fire safety control. Standards have been established for each of these broad classes and any deviation from these standards will result in a certain number of deficiency points depending on the importance of the subitems and the degree of deviation.

The fire department (includes manpower, apparatus, and fire fighting equipment) and the water supply account for 78 percent of the total points in the grading system. Fire service communications and fire safety control account for the rest of the deficiency points. In addition to this, certain deficiency points can be assigned for adverse climatic conditions such as high winds, tornadoes, or excess snowfall, and for adverse conditions or occurrences such as forest fires, civil disturbances, landslides, or floods. Further deficiencies can be assigned for an excessive divergence between the water supply and the fire department. A town could conceivably have an excellent water supply, yet have a fire department which could not effectively utilize the water

facilities available. Therefore, additional deficiency points will be given to this town.

There are 14, 17, 10 and 8 items considered under the water supply, the fire department, fire communications, and fire safety control, respectively. (See Table B-2 in Appendix B.) Each of the 14 items under water supply is investigated separately and compared to an accepted standard. If the item fails to meet the established standard, a deficiency is noted in percentage terms. The percent is then translated into a corresponding number of deficiency points against the particular item. The total deficiency points allowed for the water supply is 1,950, with each of the 14 items allotted a relative weight in terms of deficiency points. A very detailed examination is made for each broad class and their corresponding subitems.

Any utility district, county, town, or city which does not have a rating can request the ISO to evaluate their fire defenses to see if a rating can be assigned. The ISO can be contacted before expenditures are made on items in the four categories mentioned above. This can be done at the planning stage and can be done by any community regardless of whether they contemplate getting a rating assigned. Similarly, a community which already has a rating can contact the ISO about improvements they plan to make with respect to fire defenses.

Once the ISO is contacted, a team of inspectors will visit the community and check all aspects of the fire department, water supply, fire service communications, and fire safety control. After the survey, the total number of deficiency points are determined and a classification

number is assigned based on a given number of deficiency points with the highest number of deficiency points being assigned the highest classification. A community that best meets the accepted standards and has the fewest deficiency points is assigned the lowest rating. The grading process culminates in the assignment of a number ranging from 1 to 10, with one being the highest obtainable rating. The relationship between the number of deficiency points and the relative class of a community is presented in Table C-1.

The total number of possible deficiency points that a community can receive is 5,000. The community which receives 500 or less deficiency points is given a Class 1 rating, those receiving between 501 and 1,000 deficiency points a Class 2 rating, and so on. Even though a community has less than 4,001 deficiency points, it will be assigned a Class 9 rating if it has no recognized water supply. A community will be assigned a Class 10 rating if it has no fire protection, has a water supply and no fire department, has a water supply but a fire department with more than 1,755 points, or has more than 4,500 deficiency points.

TABLE C-1

THE INSURANCE SERVICES OFFICE RELATIONSHIP BETWEEN POINTS OF DEFICIENCY AND THE RELATIVE CLASS OF A MUNICIPALITY

Points of deficiency	Relative class of the municipality
0-500	First
501-1,000	Second
1,001-1,500	Third
1,501-2,000	Fourth
2,001-2,500	Fifth
2,501-3,000	Sixth
3,001-3,500	Seventh
3,501-4,000	Eighth
4,001-4,500	Ninth[a]
More than 4,500	Tenth[b]

[a]A ninth class municipality is one (a) receiving 4,001 to 4,500 points of deficiency, or (b) receiving less than 4,001 points but having no recognized water supply.

[b]A tenth class municipality is one (a) receiving more than 4,500 points of deficiency, or (b) without a recognized water supply and having a fire department grading over 1,755 points, or (c) with a water supply and no fire department, or (d) with no fire protection.

Source: Insurance Services Office, Grading Schedule for Municipal Fire Protection (New York: Insurance Services Office, Municipal Survey Service, 1973), p. 3.

VITA

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