AN ANALYSIS OF DEMAND FOR TELEPHONE SERVICE IN SELECTED OKLAHOMA EXCHANGES, 1960

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PREFACE

This thesis is concerned with the estimation of a demand function for residential telephone service in Oklahoma. This is considered to be important because the telephone industry is regulated and is required to provide adequate service. The opportunity costs which result when excess equipment is installed also make it important that telephone companies have accurate estimates of the demand functions they face. However, available data for both the independent and the dependent variables are limited and the author had to use cross-sectional data for only one year. This limits the predictive capabilities of the demand function which was estimated.

I would like to take this opportunity to express my appreciation to the following professors for their assistance and guidance: Dr. Larkin Warner, my thesis adviser, whose suggestions led to the selection of this topic and whose advice greatly improved the final product; Dr. Robert L. Sandmeyer, whose suggestions improved the readability of this paper; and Dr. Mohamad Khouja, whose assistance with the statistical work was invaluable.

I would also like to express my gratitude to Mr. Warren Hamilton and Mr. Ed Perry of Southwestern Bell Telephone Company who provided me with the information and the data which made this study possible.

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CHAPTER I

INTRODUCTION

Statement of the Problem

Southwestern Bell Telephone Company is engaged in the business of providing telephone service for the major portion of a five state area including Oklahoma. The forecast engineers for the Oklahoma division of this company attempt to estimate the annual changes in demand for telephone service in each of their exchanges[1] for an arbitrary period into the future. Reasonably accurate predictions are necessary in order to correctly allocate expenditures for plant and equipment. Southwestern Bell desires to build the correct scale of plant in each of its exchanges for two basic reasons. First, telephone companies are regulated and are required to provide adequate telephone service to all who desire service in each of their exchanges. This gives the firm incentive to install enough equipment to meet future demands in each of their exchanges. The second reason which makes accurate predictions of future telephone equipment needs necessary is directly related to the first. Although Southwestern Bell's forecast engineers want to have enough

[1]A telephone exchange is a geographical area with arbitrary boundaries set by the Oklahoma Corporation Commission. Each exchange can usually be distinguished by the prefixes of the telephone numbers. With the exception of two of Bell's Oklahoma exchanges, the telephone numbers in each exchange have unique prefixes.

telephone equipment to meet future needs, they want to avoid excess installation of equipment due to the opportunity costs that are suffered until the equipment is needed.

Scope of the Study

The hypothesis which will be examined in this study is that social and economic characteristics of the population can be found which explain changes in demand for telephone service. Also, an attempt will be made to show that the size of Southwestern Bell relative to other telephone companies in Oklahoma, together with regulation of the industry, increases the importance of determining the demand function for the firm's service.

The problem will be treated in two parts. The object of Chapter II will be to outline the structural development of the telephone industry in Oklahoma and to trace the evolution of selected aspects of the state regulatory framework of the Oklahoma telephone industry. This will be done in an effort to show how these factors increase the importance of accurate forecasting by telephone companies, especially large ones like Southwestern Bell Telephone Company.

The third chapter will be devoted to a discussion of the methods currently used in forecasting changes in demand for telephone service. The hypothesis that various social and economic characteristics explain variation in demand for telephone service will also be examined in this chapter with the aid of a step-wise multiple regression analysis.

The fourth and final chapter is reserved for an interpretation of the results and will include the conclusions of the study and some recommendations for additional work that could be done in this area.

Limitations of the Study

The primary limitation of this study results from lack of data. Annual telephone user rates for Bell's Oklahoma exchanges are not available for the years preceding 1958.[2] The lack of observations makes it impossible to run a time series analysis for each exchange, so a cross sectional analysis will be used.

There is also a data limitation relative to the independent variables that will be used in this study. Measures of social and economic characteristics, which might explain telephone user rates, are not available for geographical areas which exactly correspond to Bell's telephone exchanges. This necessitates the use of county data for several of the independent variables. It is also difficult to obtain consistent and reliable county data for years other than census years. This factor results in this study being limited to the latest census year, 1960.

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[2]A telephone user rate is the percent of occupied households in an exchange with at least one telephone. It will be used as the dependent variable when the demand function is estimated.

CHAPTER II

THE EVOLUTION OF THE TELEPHONE INDUSTRY IN OKLAHOMA, 1907-1967: SELECTED STRUCTURAL AND REGULATORY CHANGES

Introduction

The object of this chapter is twofold. The first part of the chapter will be devoted to a description of the structural changes of the telephone industry in Oklahoma since statehood. Particular emphasis will be placed on the trend toward complete dominance of Oklahoma's telephone industry by Southwestern Bell. This will be expressed in terms of both telephones and telephone companies.

The second section of this chapter will consist of an outline of the development of selected elements of the body of state regulation relative to the telephone industry. Attention will be given to the state regulation which requires telephone companies to provide sufficient equipment to meet not only the needs of their subscribers, but also the needs of other companies that wish to make connections with their lines.

The reasons which make it mandatory for Southwestern Bell to make accurate forecasts of future telephone equipment needs were outlined in the introductory chapter. The purpose of these two sections is to emphasize those reasons.

The Structure of the Telephone Industry in Oklahoma, 1907-1967

The State of Oklahoma had considerably more telephones in 1967 than it had in 1907, but the opposite was true relative to telephone companies or systems. Evidence of this can be seen in Tables I and II. The number of telephones in Oklahoma increased from 68,125 in 1907 to 1,194,800 in 1967. The overall telephone growth rate in Oklahoma appears to have been steady over the past sixty years, but this is not true when the growth rates of telephones owned by Bell and those owned by independent companies are considered separately. The total number of telephones in Oklahoma increased by 312 per cent between 1907 and 1937, and they increased by 325 per cent between 1937 and 1967. This is in contrast to the number of Bell telephones in Oklahoma which increased by 635 per cent between 1907 and 1937, while the number of independent telephones increased by only 60 per cent. The same pattern holds for the period 1937 to 1967, but it is not as striking as in the previous period. Between 1937 and 1967, the number of Bell telephones increased by 380 per cent while the independents were realizing a 125 per cent increase.

It is evident that Southwestern Bell made its most significant gain on the independent companies before 1937. Further evidence of this lies in the fact that Southwestern Bell served 44 per cent of Oklahoma'a telephones in 1907, 78 per cent in 1937, and 89 per cent in 1967.

The change in the absolute number of telephones does not tell the whole story because there has been a significant increase in Oklahoma's population since 1907. Therefore, the change in telephones per 1000

TABLE I

TELEPHONES BY CLASS OF OWNERSHIP IN OKLAHOMA, 1907, 1937, AND 1967

	Year		
	1907[a]	1937[b]	1967[c]
Total telephones	68,125	280,937	1,194,800
Bell telephones	30,116	220,260	1,058,000
Independent telephones	38,009	60,677	136,800
Per cent of total owned by Bell	44.2	78.4	88.6
Per cent of total owned by independents	55.8	21.6	11.4

Source: [a]U. S., Bureau of the Census, Special Reports, Telephones: 1907 (Washington, 1910), pp. 17, 22-23.

[b]U. S., Bureau of the Census, Census of Electrical Industries, 1937: Telephones and Telegraphs (Washington, 1939), pp. 7-8, 32-33.

[c]Unpublished data from the files of the Oklahoma Corporation Commission.

TABLE II

TELEPHONE COMPANIES AND TELEPHONE EXCHANGES
BY CLASS OF OWNERSHIP IN OKLAHOMA,
1907, 1937, AND 1967

	1907[a]	1937[b]	1967[c]
Total telephone companies	715*	1934*	59
Total exchanges	294	540	474
Bell exchanges	111	155	174
Independent exchanges	183	385	300
Per cent of total exchanges served by Bell	37.8	28.7	36.7
Per cent of total exchanges served by independents	62.2	71.3	63.3

*The data for total telephone companies in Oklahoma in 1907 and 1937 include independent farmer and rural lines which were separately owned.

Source: [a]U. S., Bureau of the Census, Special Reports, Telephones: 1907 (Washington, 1910), pp. 17, 30.

[b]U. S., Bureau of the Census, Census of Electrical Industries, 1937: Telephones and Telegraphs (Washington, 1939), pp. 7, 14, 34-35.

[c]Unpublished data from the files of the Oklahoma Corporation Commission.

population should be considered. There were approximately ten times as many telephones per 1000 population in 1965 as in 1907. Oklahoma had 48 telephones per 1000 population in 1907[1] and 451 telephones per 1000 population in 1965.[2]

While the number of telephones and the number of telephones per 1000 population have increased in Oklahoma, the number of companies or systems has decreased (Table II). In 1907, there were 715 distinct telephone systems in Oklahoma. In 1967, there were 59. It might be a bit unrealistic to compare the 1907 figure to the 1967 figure because in 1907, there were a large number of independent farmer or rural lines with each serving a very small number of subscribers. Nevertheless, each was a distinct organization in the same sense the telephone companies are today.

In 1907, approximately 80 per cent of the telephone systems in Oklahoma were independent farmer or rural lines, but they only served 23 per cent of Oklahoma's telephones.[3] The same situation existed in 1937. Of the 1,934 systems in existence at that time, 82 per cent of them were small rural connecting lines, and only seven of the 1,934 companies had annual incomes of $10,000 or more.[4]

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[1]U. S., Bureau of the Census, Special Reports, Telephones: 1907 (Washington, 1910), p. 51.

[2]U. S., Federal Communications Commission, Statistics of Communications Common Carriers for the Year Ended December 31, 1965 (Washington, 1967), p. 10.

[3]U. S., Bureau of the Census, Special Reports, Telephones: 1907 p. 27.

[4]U. S., Bureau of the Census, Census of Electrical Industries, 1937: Telephones and Telegraphs (Washington, 1939), p. 7.

According to the data in Table II, the number of exchanges served by the small independent companies increased relative to those served by Bell along with the increase in the total number of companies between 1907 and 1937. The independent companies had 71 per cent of the total exchanges in Oklahoma in 1937 compared to 62 per cent in 1907.

The development of the telephone industry in Oklahoma has paralleled that of the United States in the twentieth century. The early part of this period was marked by a rapid increase in the number of independent companies after the expiration of the original Bell patents in 1893 and 1894.[5] This trend has subsequently reversed, and there was a 97 per cent decrease in the number of telephone systems and lines in Oklahoma between 1937 and 1967 (Table II). Most of the small systems and rural lines were absorbed by either Bell or the larger independent companies until in 1967, there were only 59 commercial telephone companies in Oklahoma (Table II). One of these, Southwestern Bell, owned 89 per cent of the telephones in Oklahoma at this time even though Bell only operated from 37 per cent of the telephone exchanges in Oklahoma (Tables I and II).

Selected Aspects of Telephone Regulation in Oklahoma, 1907-1967

The main body of State regulation which requires telephone companies operating in Oklahoma to provide adequate equipment for their subscribers and other telephone companies was developed during the first

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[5]U. S., Congress, House, Investigation of the Telephone Industry in the United States, 76th Congress, 1st Session, 1939, House Doc. 340, p. 129.

thirty years of statehood. Additions to the regulatory framework since 1937 have consisted of judicial decisions and minor statutory provisions which have clarified and amended the original constitutional and statutory provisions, but the basic regulatory framework changed very little between 1937 and 1967.

State regulation of Oklahoma's telephone industry began when the Constitution of the State of Oklahoma went into force on November 16, 1907. There are two major provisions in the Oklahoma Constitution for the regulation of telephone companies. The most basic of these is the section which gives the Oklahoma Corporation Commission authority to regulate all of Oklahoma's transmission companies. "The Commission shall have the power and authority and be charged with the duty of supervising, regulating, and controlling all transportation and transmission companies doing business in this State..."[6]

The other section of the Oklahoma Constitution which provides for the regulation of telephone companies is more directly related to the problem of providing adequate telephone equipment. It requires all telephone companies to receive and transmit all telephone messages without delay. Furthermore, this section requires all telephone companies to connect with each others' lines according to the rules and regulations of the Oklahoma Corporation Commission.[7]

The requirement that telephone companies must connect with each others' lines was tested in the Oklahoma courts. One of the earliest cases arose from a dispute between Pioneer Telephone Company and Deer

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[6]Oklahoma, Constitution, Art. 9, Sec. 18.

[7]Ibid., Sec. 6.

Creek Mutual Telephone Company in Arapaho, Oklahoma.[8] Pioneer Telephone Company owned the long distance lines which passed through Arapaho, and Deer Creek Mutual provided local telephone service for the residents of Arapaho. Pioneer's refusal to connect its long distance lines with the local lines of Deer Creek Mutual resulted in the Arapaho telephone subscribers having to own two telephones in order to get both local and long distance service. The Oklahoma Corporation Commission ordered Pioneer to connect its lines to the lines of Deer Creek Mutual. Pioneer appealed the order to the Oklahoma Supreme Court on the grounds that the order requiring the connection of its lines with those of another company was equivalent to taking property without just compensation. The Court upheld the Commission's ruling, but modified its original order in an effort to insure equal treatment to both companies' subscribers after the connection was made.

In a similar case two years later, Pioneer Telephone Company tested a Corporation Commission order requiring it to connect its long distance lines with the local lines of Farmer's Mutual Telephone Company in Weatherford, Oklahoma.[9] Once again, the Oklahoma Supreme Court ruled that the connection must be made.

It was not unitl 1917 that the Oklahoma Legislature passed legislation relative to telephone regulation. The 1917 law gives Oklahoma telephone companies monopolies in their exchanges, but it also provides for the withdrawal of this privilege if a company is unable or unwilling

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[8] Pioneer Telephone and Telegraph Company v. State of Oklahoma, 71 Okl. 305, 117 p. 580 (1918).

[9] Pioneer Telephone and Telegraph Company v. State of Oklahoma, 78 Okl. 38, 188 p. 107 (1920).

to provide adequate service.[10] Section one of this act makes it unlawful for anyone to build or operate telephone equipment in an area already served by another telephone company unless "public necessity" or "public convenience" makes it desirable for another company to enter the occupied area. Section two gives the Oklahoma Corporation Commission power to decide when "public necessity" or "public convenience" requires the entrance of another telephone company into an occupied area.

The 1917 law was clarified by the Oklahoma Supreme Court in a 1937 case which arose from a Corporation Commission order which denied R. C. Simpkins the right to build and operate a telephone system in Jesse, Oklahoma.[11] The Supreme Court ruled that this area was technically open and the 1917 law did not give the Corporation Commission jusisdiction over open territory.

A 1947 Oklahoma Supreme Court decision seems to have set a precedent that enables a telephone company to avoid having to enter an occupied area just because the citizens of a given area prefer the service of another company over the service they are presently receiving.[12] The case came to the attention of the Oklahoma Supreme Court after the Corporation Commission had ordered Southwestern Bell Telephone Company to provide service for the residents of a strip of land between Nicoma Park, Oklahoma and Oklahoma City. The residents of this area preferred Bell service to Nicoma Park service primarily because if they

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[10]Oklahoma Session Laws 1917, Chapter 270, at 490-492.

[11]Simpkins v. Oklahoma Corporation Commission, 180 Okl. 108, 67 p. 2d 961 (1937).

[12]Nicoma Park Telephone Company and Southwestern Bell Telephone Company v. State of Oklahoma, 198 Okl. 441, 180 p. 2d 626 (1947).

were part of an Oklahoma City Bell exchange, they could avoid paying toll charges for calls to the Oklahoma City area. Both Southwestern Bell and Nicoma Park Telephone Company objected to this order, so they appealed to the Oklahoma Supreme Court. The Court reversed the order because it was "tantamount to an appropriation of private property for public use without just compensation." Southwestern Bell would have lost money by having to extend service to this area and Nicoma Park Telephone Company would have probably gone out of business if it were not allowed to provide service for this area.

In a more recent case, Southwestern Bell was required to invade a rival company's exchange because the Supreme Court ruled that this invasion was a "public necessity."[18] Blakely, acting on behalf of McLoud Telephone Company, appealed to the Oklahoma Supreme Court an order requiring Southwestern Bell to connect one of its Oklahoma City telephone exchanges to a dairy farm near McLoud by means of a physical connection with the McLoud switchboard. The Supreme Court upheld this order even though the McLoud Telephone Company ordinarily should enjoy a monopoly in their assigned territory. The Court ruled that the advantages to the McLoud economy of a direct connection with the milk markets of Oklahoma City were great enough to make this invasion a "public necessity."

The Oklahoma Corporation Commission has issued only one general order requiring telephone companies to provide adequate telephone service. In 1931, the Commission formulated a set of guidelines Oklahoma

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[18] Blakely v. Oklahoma Corporation Commission, Okl., 332 p. 2d 1103 (1958).

telephone companies must follow.[14] The most important regulations are as follows. All Oklahoma telephone companies are responsible for maintaining their plant and equipment so they can give satisfactory service to their subscribers. If a failure of telephone equipment occurs due to a storm or fire, the Commission must be notified and service must be promptly resumed. Each company must provide either individual or party line telephone service at the request of a subscriber and service can not be refused due to a disputed payment until the Corporation Commission rules on the dispute. Also, a telephone company can not reduce an ititial rate area without the approval of the Corporation Commission, but an initial rate area must be extended as new residential areas develop.

There was very little added to the regulatory framework of the Oklahoma telephone industry between 1931 and 1957. In 1957, the Oklahoma Legislature amended the 1917 law.[15] The 1957 statute states that the Corporation Commission can not allow a telephone company to enter into competition with another telephone company unless the latter is unwilling or unable to provide "reasonably adequate service." This statute also stipulates the penalty for failing to provide "reasonable adequate service." The 1957 law gives the Oklahoma Corporation Commission authority to declare the inadequately served territory open.

The Oklahoma Legislature went even further in 1959 when it gave the Corporation Commission authority to not only declare the inadequately

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[14] 1931 Oklahoma Corporation Commission Annual Report, Order No. 5417, at 338-341.

[15] Oklahoma Session Laws 1957, Chapter 6, at 88.

served territory open, but also the power to declare all of a company's territory open.[16] The 1959 law also gives the Corporation Commission authority to require the telephone company that can most economically serve an open area to provide service for it. This is subject to the limitation that the company must be able to earn a fair return on required investment. Any company which fails to provide adequate service under the provisions of this section can be charged with contempt and can be required to vacate all of their territory if the Corporation Commission so desires.

Summary

This chapter has been devoted to an outline of the structural evolution of the Oklahoma telephone industry and to a presentation of selected aspects of State regulation of this industry. The purpose was to emphasize the importance of these factors in making it mandatory that Southwestern Bell make accurate forecasts of the need for telephone equipment in their Oklahoma exchanges.

It was shown that Bell served 68,125 telephones in 1907 and 1,194,800 in 1967 from approximately the same number of exchanges. Their share of the total telephones in Oklahoma increased from 44 per cent in 1907 to 89 per cent in 1967. The large absolute number of telephones owned by Southwestern Bell in Oklahoma in only 174 exchanges indicates that Bell has made a very large investment in at least some of these exchanges. Small forecasting errors in these exchanges could be very costly. Another factor, which is probably more important, is that

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[16] Oklahoma Session Laws 1959, Chapter 6, at 85-86.

by owning 89 per cent of the telephones in the State, Bell is operating in most of the populous areas of Oklahoma. Rapid increases in the need for telephone equipment, and therefore, increased need for accurate forecasting, is more likely to occur in the urban areas where the population is growing than in the rural areas where the population is often declining.

The evolution of the regulation of the Oklahoma telephone companies has also made it increasingly important that companies like Southwestern Bell correctly estimate future telephone equipment needs. They are required to connect to other companies' lines and to provide adequate service to areas outside their exchanges as new residential areas develop. Inability to meet these requirements can result in penalties as severe as loss of their entire territory.

CHAPTER III

A REGRESSION ANALYSIS OF TELEPHONE USER RATES IN SELECTED OKLAHOMA EXCHANGES, 1960

Introduction

Southwestern Bell Telephone Company serves 1,058,000 telephones in Oklahoma from 174 exchanges. The other 58 companies in Oklahoma provide service in 300 exchanges, but they only serve 136,800 telephones[1] or approximately 11 per cent of the total. In an effort to provide satisfactory service for 89 per cent of the telephone users in Oklahoma, Southwestern Bell's forecast engineers attempt to forecast the change in demand for telephone service in their 174 exchanges on an annual basis for a five year period.

The purpose of this chapter is to outline the methods that Southwestern Bell's forecast engineers currently use to forecast changes in demand for telephone service in their Oklahoma exchanges and to determine additional variables that explain variation among telephone user rates in selected Oklahoma exchanges served by Southwestern Bell. A step-wise multiple regression statistical analysis will be employed in an attempt to achieve the latter purpose.

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[1]Letter from P. T. Whittemore, Assistant Utility Engineer, Oklahoma Corporation Commission, Oklahoma City, Oklahoma, August 3, 1967.

Current Forecasting Methods

The forecasts of changes in demand for telephone service in Southwestern Bell Telephone Company's 174 Oklahoma exchanges are made by a group of forecast engineers in Oklahoma City. The forecast engineers have divided the 174 exchanges into 11 districts on the basis of both geographical location and homogeneity of social and economic characteristics. Each of these 11 districts is headed by a forecast engineer who is familiar with his district and therefore, has an intuitive grasp concerning what is likely to happen that would affect the demand for telephone service in his district.[2]

For forecasting purposes, the telephone equipment in each exchange has been classified as either "inside plant" or "outside plant." "Inside plant" consists of equipment such as buildings and switchboard equipment while "outside plant" is largely telephone lines and poles. This distinction is important because forecasts for "inside plant" equipment are made on an annual basis for a five year period, but forecasts for "outside plant" equipment are made for a twenty year period and are revised every five years as pertinent factors change. Southwestern Bell's forecast engineers do not worry a great deal about the accuracy of their "outside plant" forecasts because they can usually be revised in time to alter equipment orders to correspond to their new expectations. This is not the case with "inside plant" equipment, however. This equipment often must be ordered from Western Electric at least one year before it is needed. If their estimate of needed

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[2]Interview with Warren A. Hamilton, Forecast Engineer, Southwestern Bell Telephone Company, July 7, 1966.

telephone equipment is too low, they may have trouble providing service to the degree required by the regulation that was outlined in the previous chapter. If their estimates are too high, they will not only incur opportunity costs while holding the equipment until they do need it, but also the equipment may become obsolete and have to be replaced without having been used.[3]

The first step in forecasting the need for "inside plant" equipment is to determine the number of household dwelling units[4] in each exchange. This is no small task, since the exchange boundaries usually do not correspond to municipal or county boundaries. This problem is solved by a periodical count of the household dwelling units in each exchange. The number of building permits issued in each exchange is often used to update the estimate between actual physical counts of household dwelling units.[5]

After the number of household dwelling units existing in each exchange at some point in time is ascertained, an attempt is made to forecast annual changes in the number of households for a five year period. The criteria used in these forecasts vary from exchange to exchange. Ordinarily, each forecast engineer contacts various individuals and organizations in each exchange in an effort to determine the expected level of economic activity in the exchange's major industries over the next five years. After obtaining this information, each forecast

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[3]Ibid.

[4]Southwestern Bell's forecast engineers define a household dwelling unit to be an occupied place of residence.

[5]Interview with Warren A. Hamilton, Forecast Engineer, Southwestern Bell Telephone Company, February 8, 1966.

engineer estimates the annual change in the number of household dwelling units by exchange for a five year period.[6]

The next step is to estimate the per cent of household dwelling units that will actually have a telephone installed as of December 31 of each year in the five year period under consideration. This percentage is called the telephone user rate. One of the primary factors used in estimating this rate is the number of new housing units expected to be constructed. This is considered to be an important variable because the forecast engineers have found that most people who build or buy a new house install at least one telephone. This usually increases the telephone user rate in that exchange. The expected level of economic activity is also taken into consideration when these projections are made. Southwestern Bell's forecast engineers do not attempt to quantify the expected level of economic activity in each exchange. Telephone user rates are projected on the basis of an intuitive measure which is made after Chamber of Commerce personnel and prominent people in the area's major industries are consulted.[7]

After the number of households and the expected telephone user rates are determined, it is a simple matter to compute the number of telephones that are expected to be in use in each exchange on a given date. Therefore, the amount of "inside plant" equipment that will be needed to provide adequate service for these telephones can also be easily determined. The remainder of this chapter will be devoted to an examination of variables and methods that could be used in improving

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[6]Ibid.

[7]Ibid.

the accuracy of these projected telephone user rates.

Proposed Forecasting Methods

A step-wise regression statistical analysis will be used to determine the degree to which selected independent variables explain variation in the dependent variable, the telephone user rate. The independent variables will be discussed in the next section. The data for the dependent variables were obtained from the records of Southwestern Bell Telephone Company. Due to the lack of data, it is impossible to make a meaningful time series regression analysis at the present time. Cross sectional data were obtained for 57 Oklahoma exchanges served by Southwestern Bell Telephone Company on December 31, 1960. These exchanges contain the largest town or city in 57 of Oklahoma's 77 counties. Southwestern Bell serves the largest town or city in 59 Oklahoma counties, but Oklahoma County and Tulsa County were excluded due to the large number of telephone exchanges in each of these cities. The year 1960 was chosen due to the lack of consistent and reliable data for areas smaller than states for other years.

A step-wise regression analysis will be used instead of a standard multiple regression analysis because the step-wise procedure makes it easier to determine the contribution of each independent variable and, therefore, it is possible to achieve a better final regression equation than the standard multiple regression analysis permits.

The step-wise procedure operates as follows. The independent variable that is most highly correlated with the dependent variable is entered into the equation first. The partial correlation coefficients are used to determine which variable enters the equation next. After the

second variable is entered into the equation, a partial F test is used to determine if the first variable should remain in the equation. This is the primary advantage of the step-wise regression procedure. That is, each variable is treated as if it were the most recent variable to be entered into the equation. Any variable whose partial F value is less than its corresponding tabulated F value is removed from the equation. This procedure continues until all of the independent variables have either entered the regression equation or have been rejected by means of the partial F criterion. After this procedure ends, the best regression equation is automatically selected.[8]

The Independent Variables

An attempt was made to choose independent variables which reflect the social and economic characteristics that determine the residential demand for telephone service. The specific independent variables are presented below along with some discussion as to why they were chosen.

Median Family Income

Median family income[9] was chosen because it is considered to be one of the best measures of each family's economic ability to have a telephone. Another factor which led to its choice as an important variable relative to telephone user rates was a comparison of the median family

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[8]N. R. Draper and H. Smith, Applied Regression Analysis (New York, 1967), pp. 171-173.

[9]The median family income figures are county data reported in the U. S. Census of Population: 1960, General Social and Economic Characteristics, Oklahoma, since median family income data is not available for each exchange.

income of telephone users to the median family income of those without telephones in the United States. In 1964, households with telephones had a median family income of $7,281 in comparison with a median family income of $3,386 for families without telephones.[10] This implies at least some degree of correlation between median family income and telephone user rates, but this, by itself, is not enough to validate median family income as an independent variable. There must also be a functional relationship between the independent and the dependent variable which requires the direction of causation to be from the independent variable to the dependent variable. It seems reasonable to assume that a functional relationship exists in this case because higher median family incomes should allow more households to have telephones, but there is no apparent reason to hypothesize that higher telephone user rates result in higher median family incomes.

One Party City Residence Rates

Another important variable is the price of telephone service. There may be both income and substitution effects of different residential rates for telephone service. Lower rates increase real incomes and more households can install telephones. Lower rates may also result in the substitution of telephone service for other means of communication. Since each exchange included in this study contains the largest city or town in each county, the rate for one party city residence service in each exchange was chosen as a measure of the price of telephone service.

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[10]U. S., Bureau of the Census, Current Population Reports: Population Characteristics, "Characteristics of Households with Telephones, March 1965," Series P-20, No. 146 (December 27, 1965), p. 1.

There is evidence that telephone companies consider the demand for telephone service to be inelastic with respect to price because they always expect an increase in total revenue when they request an increase in rates from their regulatory commission. Indeed, they sometimes behave as though they assumed demand to be perfectly inelastic.[11] Demand for telephone service may be inelastic with respect to price becuase total expenditures on telephone service usually make up a very small part of a family's total expenditures. Even if this is the case, it seems doubtful that the demand for telephone service is perfectly inelastic with respect to rate differentials. Therefore, one would expect lower telephone user rates in exchanges with higher telephone rates.

Per Cent of Total Population Who Moved Into House After 1958

The next variable to be considered is one which primarily reflects need for telephone service.[12] It is hypothesized that people who move frequently are less likely to install a telephone than those who are less mobile. One of the reasons for this hypothesis is that people who move from one community to another frequently will ordinarily have fewer local acquaintances and therefore, less need for a telephone for social purposes. The fee charged to install or transfer a telephone may also deter those who move frequently from having a telephone. This hypothesis is supported by data collected in March 1960, for the United States.

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[11] C. Emery Troxel, "Telephone Regulation in Michigan," Utility Regulation: New Directions in Theory and Policy, ed. William G. Shephard and Thomas G. Geis (New York, 1966), p. 152.

[12] The data for this variable were obtained from 1960 Census data, so this per cent could be adjusted to an annual figure if the actual data collection date were known.

At that time, 57.6 per cent of the population who moved in 1959 had telephones compared to 74.7 per cent of the total population and 78.7 per cent of the population living in the same house in 1960 as they did in 1959 who had telephones.[13]

Urban Population Expressed as a Percentage of Total Population in Each Exchange

Another factor which might be an important determinant of telephone user rates is the degree of the population of an exchange is located in an urban area.[14] Including this variable may cause some statistical problems because urban families usually have higher median family incomes than rural families and median family income has already been included as a separate variable. If the difference between the median income of rural and urban families is very great, it is likely that a great deal of multicollinearity will result between these two independent variables.

With the above mentioned problem in mind, the degree of urbanization is being included in the present study because it is considered to be an important variable for reasons that are not associated with income. Its importance arises from two factors. First, rural families have fewer services available to them in their immediate vicinity and

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[13]U. S., Bureau of the Census, Current Population Reports: Population Characteristics, "Characteristics of Households with Telephones, March 1960," Series P-20, No. 111 (August 2, 1961), p. 6.

[14]The data for each exchange were generated by multiplying the average number of persons per household in each county by the number of households in the respective exchanges to obtain an estimate of the total population in each exchange. This figure was then divided into the total urban population figure for each exchange.

therefore, less need for a telephone. An example of this is delivery services of various kinds. Another factor which is probably more important in discouraging rural families from having telephones is the fact that one party telephone systems are often not available to rural families. The inconvenience of multiple party telephone systems may cause rural families to forego having a telephone installed.

Evidence of lower telephone user rates among rural families is available for the United States in 1958 and in 1960. In 1958, 72.5 per cent of the households in the United States had telephones, while the rates were 66.3 and 49.4 for rural non-farm and farm households, respectively. This is compared to 78.6 per cent of urban households with telephones.[15] In 1960, the situation was similar to that in 1958 except only a rural urban comparison is available. In 1960, the national user rate was 74.7, the urban rate was 79.2, and the rural rate was 66.9.[16]

Per Cent of Total Housing Units Constructed 1959 to March 1960

The final independent variable to be considered is one that is designed to determine the effect new houses have on telephone user rates.[17] As was previously mentioned, Southwestern Bell's forecast engineers expect this variable to be of primary importance in

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[15]U. S., Bureau of the Census, Current Population Reports: Population Characteristics, "Characteristics of Households with Telephones, March 1958," Series P-20, No. 95 (November 9, 1959), p. 2.

[16]U. S., Bureau of the Census, Current Population Reports: Population Characteristics, "Characteristics of Households with Telephones, March 1960," p. 5.

[17]The data for this variable were generated from 1960 U. S. Census of Housing county data. It would be preferable to use the per cent of total housing units constructed in 1960, but this is not possible.

forecasting telephone user rates. Their confidence in this variable is based on the contention that almost everyone who moves into a new house installs at least one telephone and ordinarily, this increases the telephone user rate.

It seems likely that this variable may be correlated with two of the independent variables discussed above. On an *a priori* basis, it is reasonable to assume that larger median family incomes are positively correlated with the construction of new houses, and the more housing units constructed after 1958, the larger the per cent of the total population who moved into a house after 1958. At the risk of encountering multicollinearily, the per cent of total housing units constructed in 1959 to March 1960 will be used as an independent variable in the analysis that follows.

Variable Transformations

The first decision one must make after it is decided to use a regression analysis is what model best fits the data. For computational and interpretation purposes, it is desirable to use the simplest possible regression model. Sometimes when it is not possible to use a simple model with the original variables, the variables can be transformed. The purpose of variable transformation is to make it "possible to work with a simple functional form in transformed variables rather than with a more complicated form in the original variables."[18]

The variables will be transformed into logarithmic form in the

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[18]G. E. P. Box and Paul W. Tidwell, "Transformation of the Independent Variables," Technometrics, IV (1962), p. 531.

regression analysis that follows because it appears that the relationship between the dependent and the independent variables is not entirely linear. The procedure used in the transformation of the original variables is to take the natural logarithm of each observation and then fit a linear function to the new data. This process achieves approximately the same results as fitting a logarithmic function with the original variables and it has the advantage of greater simplicity.

The Results of the Regression Analysis

The purpose of this section is to present the results of regressing the telephone user rates in 57 of Southwestern Bell's Oklahoma exchanges against the five independent variables discussed above.

The regression coefficients and the multiple correlation coefficients derived at each step in the step-wise procedure are presented in Table III. Median family income was the first variable to be entered into the regression equation. The sign of its regression coefficient is positive, as was expected, and it is significant at the one per cent level. In fact, this variable explains approximately 69 per cent of the total variation in telephone user rates. The next independent variable entered into the regression equation was the per cent of the total population who moved after 1958. Its regression coefficient has a negative sign and is significant at the five per cent level. The negative sign of this variable is consistent with its theoretical development presented above. None of the other three independent variables are statistically significant. Each of them increases the value of the multiple correlation coefficient, but the addition of each variable also reduces the residual degrees of freedom which increases the residual mean

TABLE III

REGRESSION COEFFICIENTS OF FIVE INDEPENDENT VARIABLES ON TELEPHONE USER RATES IN 57 OKLAHOMA EXCHANGES, 1960. (N = 57)

Step	Multiple correlation coefficient	R^2	Regression Coefficients				
			Median family income	% who moved into house after 1958	% of total population which is urban	% of housing units constructed 1959 to March 1960	One party city residence rates
1	.82811**	.68576	.43804**				
2	.84386**	.71209	.46255**	-.11292*			
3	.84537**	.71465	.45634**	-.08312		-.01674	
4	.84570**	.71520	.46308**	-.07292		-.01717	-.04609
5	.84588**	.71551	.46051**	-.07724	.00114	-.01634	-.05278

*Significant at the .05 level

**Significant at the .01 level

square. Through this process, the addition of these three variables actually reduces the overall F value.[19]

One of these variables presents another problem. The signs of the coefficients for the per cent of housing units constructed 1959 to March 1960, are negative, and this variable was hypothesized to be positively correlated with the dependent variable.

Also, there may be multicollinearity between several combinations of the independent variables. Evidence of this can be seen in Table IV where the simple correlation coefficients between the five independent variables are presented. The largest simple correlation coefficient is between the per cent who moved into house after 1958 and the per cent of housing units constructed 1959 to March 1960. In an effort to eliminate some of this multicollinearity, the per cent of housing units constructed 1959 to March 1960, was removed from the regression equation in a second run. This variable was chosen over the per cent of the total population who moved into a house after 1958, because the latter was significant in the initial regression equation, and the per cent of housing units constructed 1959 to March 1960 was not significant.

The regression coefficients resulting from regressing the telephone user rates in the 57 exchanges against the four remaining variables are presented in Table V. The only noticeable change in the results is that the per cent who moved into house after 1960 is still statistically significant at the .05 level in step three with one party city residence rates in the equation. The per cent who moved into house after 1958 was significant only in step two of the initial analysis.

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[19]Draper and Smith, p. 118.

TABLE IV

SIMPLE CORRELATION COEFFICIENTS BETWEEN INDEPENDENT VARIABLES (N = 57)

Variable	Median family income	% who moved into house after 1958	% of total population which is urban	% of housing units constructed 1959 to March 1960	One party city residence rates
Median family income	1.0000	.27449	.42873	.00745	.52638
% who moved into house after 1958		1.0000	.39325	.62480	.55018
% of total population which is urban			1.0000	.09225	.47155
% of housing units constructed 1959 to March 1960				1.0000	.24646
One party city residence rates					1.0000

TABLE V

REGRESSION COEFFICIENTS OF FOUR INDEPENDENT VARIABLES ON TELEPHONE USER RATES IN 57 OKLAHOMA EXCHANGES, 1960 (N = 57)

Step	Multiple correlation coefficient	R^2	Regression Coefficients			
			Median family income	% who moved into house after 1958	% of total population which is urban	One party city residence rates
1	.82811**	.68576	.43804**			
2	.84386**	.71209	.46255**	-.11292*		
3	.84412**	.71253	.46863**	-.10461*		-.04061
4	.84448**	.71314	.46469**	-.10849	.00158	-.05026

*Significant at the .05 level

** Significant at the .01 level

Since the removal of the per cent of housing units constructed 1959 to March 1960 did not significantly improve the results and since there still appears to be multicollinearily between some of the variables, an additional variable was removed in a third run. The urban population expressed as a percentage of the total population in each exchange, was removed because it seemed to add the least to the explanatory power of the other variables, and it is also highly correlated with median family income, the per cent who moved into house after 1958, and one party city residence rates according to the coefficients in Table IV.

The results of regressing the dependent variable against the three remaining independent variables can be seen in Table VI. It appears that the response with these variables is slightly inferior to the response in the previous example because the per cent who moved into house after 1958 is no longer significant in step three, but it is possible that the response has actually increased because the removal of an independent variable has increased the residual degrees of freedom, and at least, the degree of multicollinearity between the variables has been decreased.

The next step was to remove one party city residence rates and replace it with the per cent of the total population which is urban. This was necessary because the former appeared to be highly correlated with median family income, the per cent who moved into house after 1958, and the per cent of the population which is urban. The results of this run are presented in Table VII. The per cent of the population which is urban is not statistically significant and does not improve the response of median family income and the per cent who moved into house after 1958. Median family income and the per cent of the total population

TABLE VI

REGRESSION COEFFICIENTS OF THREE INDEPENDENT VARIABLES ON TELEPHONE USER RATES IN 57 OKLAHOMA EXCHANGES, 1960 (N = 57)

Step	Multiple correlation coefficient	R^2	Regression Coefficients: Median family income	% who moved into house after 1958	One party city residence rates
1	.82811**	.68576	.43804**		
2	.84386**	.71209	.46255**	-.11292*	
3	.84412**	.71253	.46863**	-.10461	-.04061

*Significant at the .05 level

**Significant at the .01 level

TABLE VII

REGRESSION COEFFICIENTS OF THREE INDEPENDENT VARIABLES ON TELEPHONE USER RATES IN 57 OKLAHOMA EXCHANGES, 1960 (N = 57)

Step	Multiple correlation coefficient	R^2	Regression Coefficients: Median family income	% who moved into house after 1958	% of total population which is urban
1	.82811**	.68576	.43804**		
2	.84386**	.71209	.46255**	-.11292*	
3	.84410**	.71250	.45825**	-.11758*	.00126

*Significant at the .05 level

**Significant at the .01 level

who moved into a house after 1958 explain 71.21 per cent of the variation in telephone user rates while the explanatory power of the other three variables in this analysis is totally insignificant.

Summary

This chapter has been devoted to a discussion of the methods used by Southwestern Bell Telephone Company's forecast engineers in forecasting telephone user rates in their telephone exchanges and to a regression analysis of selected variables that were hypothesized to be useful in explaining variations in these rates. According to the results of the regression analysis, a variable Bell's engineers have used heavily in forecasting telephone user rates is insignificant. This variable, the per cent of total housing units constructed 1959 to March 1960, also appears to be negatively correlated with telephone user rates in contrast to their expectations. A clue to the cause of this negative sign can be found by examining the simple correlation coefficient between this variable and the per cent of the total population which moved after 1958 (Table IV). According to Table IV, the simple correlation coefficient between these two variables is .62480. Therefore, since the rate of construction of new houses is high in areas where the population is mobile, the positive effects of new housing construction on telephone user rates may be more than offset by the negative effects of a highly mobile population. Evidence of this can be seen by examining the data for the counties with large military bases. Comanche, Jackson, and Washita counties have very mobile populations and very high rates of new housing construction, but the telephone user rates in these counties are not very high. Family income and mobility of the population appear

to be the most useful factors in explaining telephone user rates according to the regression analysis that was performed in this chapter.

CHAPTER IV

INTERPRETATION OF THE RESULTS

Conclusions

This study has involved an examination of two hypotheses. The first hypothesis stated that State regulation and the dominance of the Oklahoma telephone industry by Southwestern Bell increase the importance of accurate forecasts of future telephone equipment needs by Bell's forecast engineers. The evidence seems to support this hypothesis. It was found that Bell provides service for more than one million Oklahoma telephones from 174 exchanges. This is in contrast to the 58 other telephone companies in Oklahoma which provide service for approximately 130,000 telephones from 300 exchanges. The fact that Bell serves nine times as many telephones from fewer exchanges indicates that Bell is responsible for providing service for the populous urban areas of the State. It seems reasonable to expect the demand for telephone service to increase more rapidly in these areas than in the rural sections of the State where the population is often declining. Therefore, telephone companies serving the populous urban areas of Oklahoma need more accurate forecasting methods than the companies serving the rural areas.

The State regulation of the Oklahoma telephone industry seems to be formidable enough to give Southwestern Bell incentive to make adequate provisions for being able to provide satisfactory telephone service on

demand. Penalties for failing to do this can be as severe as being required to vacate their territory. It seems doubtful that the Oklahoma Corporation Commission will require Southwestern Bell to do this, but Bell must connect their lines to other companies' lines. Furthermore, they must not only provide adequate service in their assigned exchanges, they must also provide service for outlying areas as residential areas expand.

The other hypothesis which was examined in this study was that social and economic characteristics of the population can be used to explain variation in telephone user rates. Of the five social and economic characteristics used as independent variables in the regression analysis, only two were statistically significant. One of these, median family income, was significant at the .01 level with a regression coefficient in excess of .4 with or without the other independent variables in the regression equation. A measure of the population's mobility between houses was significant at the .05 level. The results indicate that there is a positive relationship between median family income and telephone user rates and an inverse relationship between the mobility of the population and telephone user rates as was expected. These two variables explained almost 72 per cent of the variation in telephone user rates. With explanatory power of this degree, these variables might be useful in forecasting telephone user rates.

Recommendations for Additional Study

One of the primary limitations of this study was the lack of data. When enough observations for the dependent variable become available, perhaps the explanatory power of the independent variables could be

tested with a time series analysis for each of Southwestern Bell's Oklahoma exchanges. The problem of lack of data for the independent variables would still exist, but estimates of median family income by counties may be a close approximation of the median family income in the largest telephone exchange in each county. Perhaps a measure of the mobility of each exchanges' population could be constructed from utility records of meter connections and disconnections. Telephone user rates could be regressed against annual estimates of these variables for each of Bell's exchanges in a time series analysis.

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APPENDIX A

TELEPHONE USER RATES USED AS DEPENDENT VARIABLE BY EXCHANGE AND COUNTY IN OKLAHOMA, 1960

County	Exchange	(Per Cent) Telephone User Rate
Alfalfa	Cherokee	83.8
Atoka	Atoka	58.3
Beckham	Elk City	74.3
Bryan	Durant	66.5
Caddo	Anadarko	63.6
Canadian	El Reno	85.0
Carter	Ardmore	76.5
Cherokee	Tahlequah	53.4
Choctaw	Hugo	58.6
Cleveland	Norman	90.0
Coal	Coalgate	61.0
Comanche	Lawton	73.4
Cotton	Walters	72.3
Craig	Vinita	76.8
Creek	Sapulpa	76.2
Custer	Clinton	68.1
Garfield	Enid	80.1
Garvin	Pauls Valley	73.4
Grady	Chickasha	76.1
Grant	Medford	87.3
Greer	Mangum	83.0
Haskell	Stigler	69.2
Hughes	Holdenville	70.7
Jackson	Altus	77.3
Jefferson	Wawrika	64.1
Johnston	Tishamingo	56.4
Kay	Ponca City	77.9
Kiowa	Hobart	75.1
Latimer	Wilburton	56.8
Lincoln	Chandler	72.3
Logan	Guthrie	75.0
Love	Marietta	59.9
McCurtain	Idabel	55.7

County	Exchange	(Per Cent) Telephone User Rate
Major	Fairview	80.8
Marshall	Madill	65.8
Mayes	Pryor	81.9
Muskogee	Muskogee	78.4
Noble	Perry	84.5
Nowata	Nowata	82.9
Okfuskee	Okemah	67.7
Okmulgee	Okmulgee	72.3
Osage	Pawhuska	77.3
Ottawa	Miami	78.2
Pawnee	Cleveland	77.7
Payne	Stillwater	79.1
Pittsburg	McAlester	72.1
Pontotoc	Ada	74.0
Pottawatomie	Shawnee	79.1
Pushmataha	Antlers	57.4
Rogers	Claremore	73.5
Seminole	Seminole	73.3
Sequoyah	Sallisaw	52.1
Stephens	Duncan	79.0
Washington	Bartlesville	95.3
Washita	Cordell	76.2
Woods	Alva	82.4
Woodward	Woodward	82.9

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