STRATEGIC PLANNING FOR RURAL SERVICE IMPROVEMENT AT THE MANITOBA TELEPHONE SYSTEM-A SYSTEM MODELLING APPROACH

by

TOM L. SCHAFFNIT

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ABSTRACT

The rapid changes in the telecommunications industry are driven by the accelerating pace of technological innovation, and the ever more sophisticated communications of the global community. The Manitoba Telephone System is the crown corporation that provides telephone and other telecommunications services within the province of Manitoba. As a crown corporation, the Manitoba Telephone System is subjected to higher levels of political pressure than a 'private sector' company. The present climate in the province has placed rural service improvement quite high on the political priority list. Such rural service improvement programs typically have capital requirements of hundreds of millions of dollars, so program decisions are rather significant to the financial well-being of a telephone company. Of the possible areas for improvements to rural telephone service in Manitoba, customers have indicated that the highest priority is the conversion of multi-party to single-party service. There are a number of possible program options that could be employed to implement the conversion to single-party service. Since planning decisions for such programs are based upon the analysis of complex interrelationships, among a large number of variables, advanced methods of analysis of strategic alternatives are needed. In order to investigate the impact of such policy alternatives upon the network planning of the Manitoba Telephone System, a descriptive model of relevant portions of the telephone system has been assembled using the methodology of Systems Dynamics. This model has been programmed in DYNAMO to allow computer simulation of the alternative policy directives.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The telecommunications industry is in a transition, turmoil, or opportunity stage, depending upon one's perspective. The rapid changes in this industry are driven by the accelerating pace of technological innovation, and the ever more sophisticated communications needs of the global community (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986, Brock 1981, Beauvais 1984, Communications Canada 1987). It has been said that the telecommunications networks, or 'electronic highways', are as essential to the Information Age as the transportation infrastructure was to the Industrial Age (Forester 1987, Communications Canada 1987). Telephone companies have evolved into telecommunications companies, providing the 'electronic highways' that carry voice and data communications by using the constantly evolving Public Switched Telephone Network (PSTN) that was originally built to provide basic telephone service.

In Manitoba, the Manitoba Telephone System (MTS) is the crown corporation that provides telephone and other telecommunications services within the province. Although telecommunications has historically been a regulated monopoly within

Canada, competition has emerged in a number of areas (for example, terminal equipment and private lines) (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986). Universal service - basically, the provision of telecommunications services to everyone - provides the historic rationale for the existing monopolistic structure within the telecommunications industry (Littlechild 1979, United States General Accounting Office 1986).

As a crown corporation, the Manitoba Telephone System is subjected to higher levels of political pressure than a 'private sector' company. Many of the policy decisions are motivated to a much greater extent by political pressure than by technological or economic influences (Langford 1986). The present climate in the province has placed rural service improvement quite high on the political priority list. Other prairie telephone companies have announced extensive programs to improve telephone service in rural areas, which has increased the pressure on the Manitoba Telephone System to make similar improvements. Such programs typically have capital requirements of hundreds of millions of dollars, so program decisions are rather significant to the financial well-being of a telephone company. Since these decisions are based upon the analysis of complex interrelationships among a large number of variables, advanced methods of analysis of strategic alternatives are needed.

Rural service improvement is a policy area that illustrates many of the fundamental concepts of telecommunications policy. The dilemma associated with rural service improvement is that the cost of providing services in rural areas is substantially higher than in areas of higher population density. These higher costs are mainly the result of two factors: (1) The capital and maintenance costs for the access loop (basically, wires to the customers premises) are higher in rural areas because the average distance to each customer from the telephone exchange office is much greater than in urban areas, and the costs of these access loops are proportional to distance, and (2) the economics of the switching equipment used in telephone exchange offices favour larger offices - thus, the offices in small, rural communities exhibit a higher switching equipment cost per customer. In spite of these increased costs, the revenues that are available from rural service are lower than for service in larger urban areas due to the rating principle of 'value of service' - which specifies a higher basic monthly rate for exchanges that include a larger number of customers. Over the last ten years, for example, the rates charged in Winnipeg have been approximately fifty percent higher than those charged for similar service in local exchange areas with fewer than 500 customers (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986, Littlechild 1979).

The area of rural service improvement includes all aspects of improving telephone service to rural customers. Potential improvements include: (1) provision of more trunk lines between switching offices, so that calls between offices are less likely to be blocked during busy calling periods, (2) replacement of older, analogue switching equipment with modern, digital equipment - which provides quicker, quieter switching, and allows new services (such as call waiting and call forwarding) to be offered, (3) extension of extended area service - allowing toll-free calling between switching offices over wider geographic areas, and (4) conversion of multi-party service to single-party service. Multi-party service refers to party lines - where two, or more customers share the same telephone line. Single-party service refers to the use of a single, private telephone line for each customer. Of the possible areas for improvements to rural telephone service in Manitoba, customers have indicated that their highest priority is the conversion of multi-party to single-party service. This priority is the result of customers' concerns for access to the telephone line when they need to make a call, and the lack of privacy on multi-party lines (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986, Criterion 1987).

1.2 PURPOSE OF THIS PAPER

The purpose of this paper is to evaluate alternative policies that may be employed by the Manitoba Telephone System to implement a program for the conversion of multi-party to single-party service. Limiting the study to the provision of single-party service to multi-party customers establishes manageable dimensions to the area of study, and addresses the main priority area for rural service improvement. The priority for this type of program stems from the aforementioned activities of other prairie telephone companies, the campaign issues of recent provincial elections in Manitoba, and market research studies of the needs of rural telephone subscribers (Criterion 1987).

There are a number of possible program options that could be employed to implement the conversion to single-party service. The two major categories of programs are: Premium Service and Universal. In a Premium Service program, the individual customer pays all, or a portion of the capital cost associated with converting his service to single-party. The primary policy decisions relating to this type of program are the level of cost charged to the individual customer. In a Universal program, all multi-party lines would be converted to single-party service on an area-by-area basis, and the cost would be borne by the rates that are charged to all customers. The policy decisions relating to this type of program centre on the timing of the program - how soon can the program start, and how long will it take to convert all multi-party customers to single-party service. Program options within Premium Service and Universal program frameworks comprise the alternatives evaluated in this study.

In order to investigate the impact of such policy decisions upon the network planning of the Manitoba Telephone System, a process model of relevant portions of the telephone system has been assembled using the methodology of System Dynamics. This model has been programmed in DYNAMO to allow computer simulation of the alternative policy directives. A description of the model and experiments conducted with it to probe its behaviour under different policy directives follows.

CHAPTER 2

SYSTEM OVERVIEW

2.1 METHODOLOGY

The methodology adopted in this study is known as System Dynamics. For a description of the System Dynamics method see Coyle (1977) and Roberts et al (1983). The rationale for using such a simulation process to model complex systems has been described by Forrester (1982, pp. 3-10) as:

> Most dynamic behavior in social systems can only be represented by models that are nonlinear and so complex that analytical mathematical solutions are impossible. For such systems, only the simulation process using step-by-step numerical solution is available.

This modeling technique offers a tool that has been successfully applied in other policy situations where complex interrelationships of variables obscure the expected results of policy decisions (Hall 1976, Hall and Menzies 1983). This tool is not intended as an exact econometric model, but instead offers an aggregate level working model of the system under study with the capability of evaluating the long-term dynamic effects of various strategic alternatives.

Complex interrelationships are modeled in System Dynamics by constructing a system flow diagram to represent the operation of the system. The system flow diagram is constructed from the 'cognitive maps' that decision makers have developed to explain their particular understanding of the operation of their part of the system, and their views of the 'causal links' that relate their part of the system to other parts. The system flow diagram is constructed, bit by bit, from the 'causal link' interconnections of various 'cognitive maps', based upon discussions with the decision makers (Axelrod 1976).

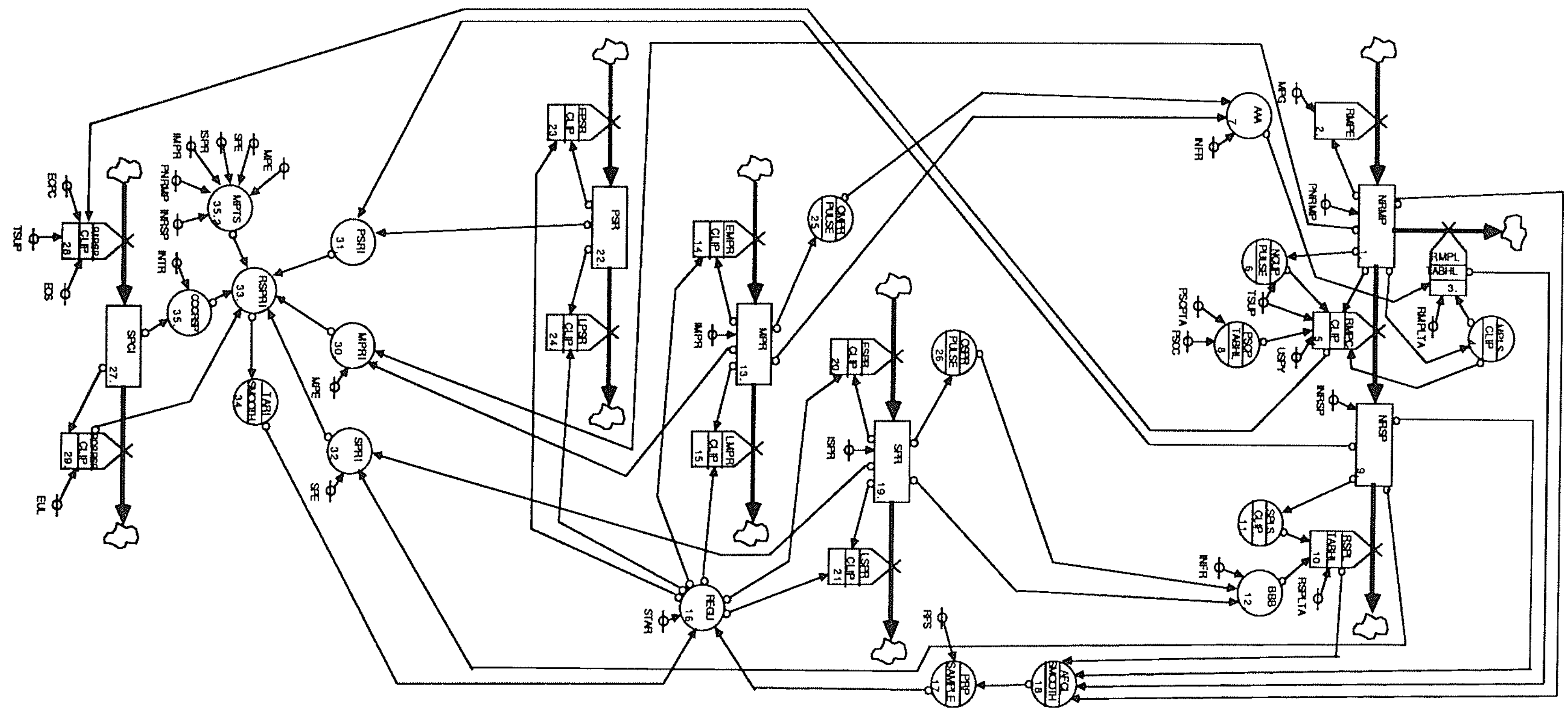
A system flow diagram so constructed represents an excellent medium for communicating the model to the decision makers upon whose 'cognitive maps' the model is based. This communication results in further clarification of the modeling assumptions, as well as a dynamic revision and refinement process for the model.

DYNAMO (Pugh 1983) is the modeling-simulation software package used to aid in building a simulation model of the system under study. This package is used because: (1) the close relationship of the DYNAMO dynamic modeling computer simulation language to the system flow diagram (Dynamo offers a one-to-one correspondence between the required equations and the elements of the system flow diagram), and (2) in the Dynamo language the order of the equations is not important, thus allowing model revisions and refinements to be easily accommodated.

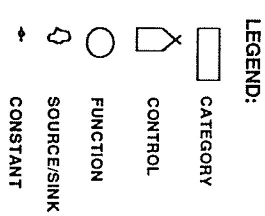
It is important to consider some of the terms that are used in this study to describe common elements of the modelling process. In a Systems Dynamics study, such as this one, the focus is on how many of some specific things (for instance, people or dollars) are in a particular <u>category</u> at each point of time in the model simulation. To illustrate the modelling process, a simple model - containing only one category - is examined. Suppose the single category of interest is the number of people who are taxpayers in Canada. It would be necessary to find out how people moved into, and out of this category. The source of potential taxpayers is outside the system being modelled, and might include people who are too young to work, as well as people who reside outside Canada. What is important to the model is determining how many of these non-taxpayers will become taxpayers at each increment of time. The model uses a control to represent the movement of people from the source to the taxpayer category. Such a control would be analogous to a faucet for controlling water, or a volume adjustment controlling the sound level of a stereo set. Similarly, when existing taxpayers move out of the country, or die, they move out of the category of taxpayers. Another control in the model represents this movement out of the category, and into the sink of former taxpayers (who are outside the model). Thus, this model represents the number of people in the Canadian taxpayer category at a series of points in time. If the initial value for the number of taxpayers is correct, and if the equations for the controls into and out of the taxpayer category accurately reflect real conditions, then this model should be able to indicate the expected number of taxpayers at any particular point in time after the initial time. The terms: category, source, sink and control are used in the same way in the following sections to describe the rural service improvement model used in this study.

FIGURE 1

SYSTEM FLOW DIAGRAM



CUSTOMER SECTOR | RATES & REGULATION SECTOR | FINANCIAL SECTOR



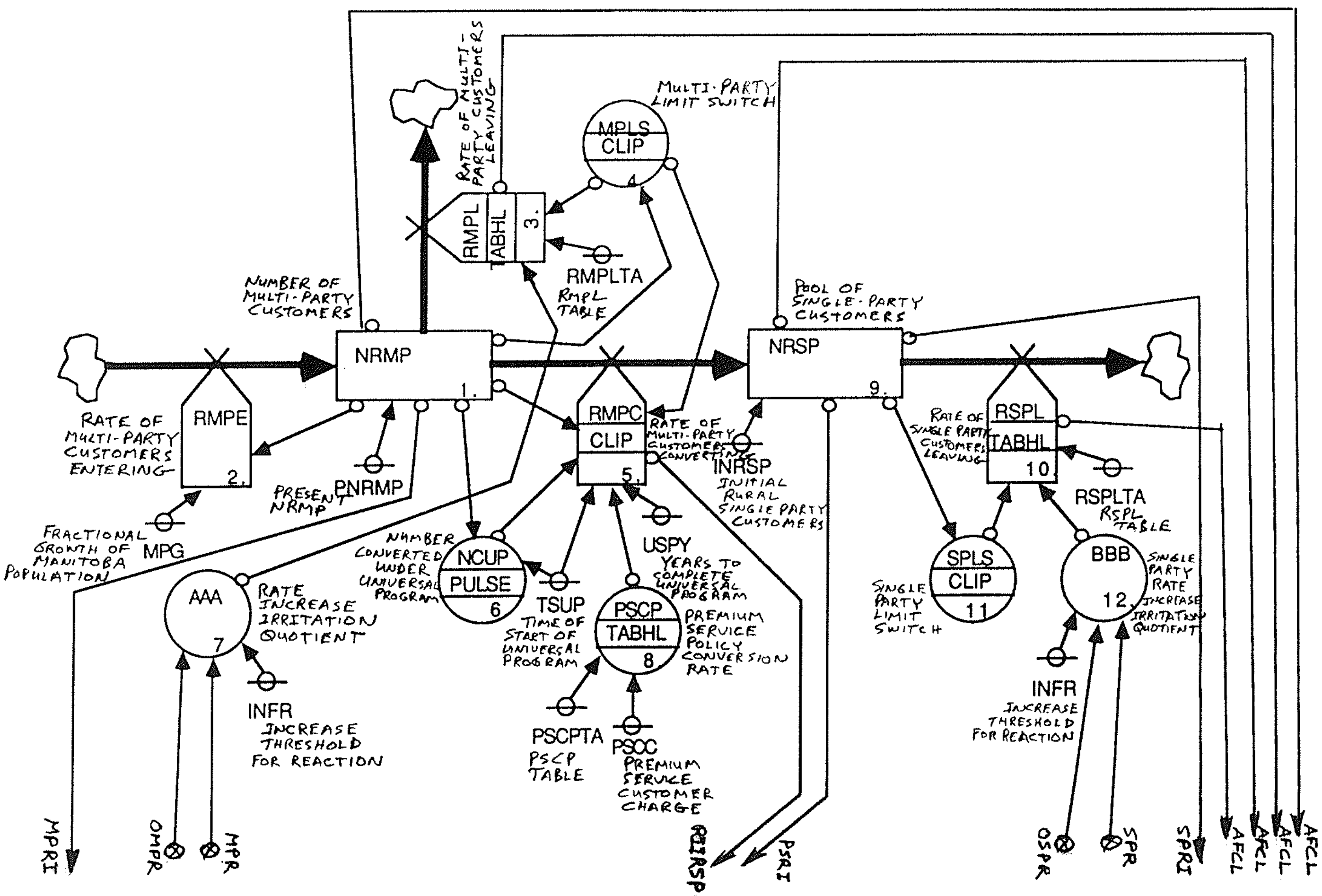
2.2 MODEL OVERVIEW

Figure 1 shows a system flow diagram representing the conglomeration of the various portions of the telephone system that are relevant to the evaluation of the policy alternatives mentioned in the first chapter. Although this total system diagram is complex, it becomes more understandable as the major subsystems are individually examined, and the general meanings of the symbols used in the diagram are described. The total system diagram is divided into three major subsystems: (1) Customer Sector, (2) Rates and Regulation Sector, and (3) Financial Sector. The operation of the total system is best described by discussing each major subsystem individually. Detailed system flow diagrams for each sector are presented in Figures 2-4. An alphabetical list of the definitions of variables used in the model is presented in Table 1 at the end of this chapter.

The Customer Sector (Figure 2) models the number of customers in various categories, and the rates at which customers enter or leave these categories. Referring to Figure 2, the larger arrows represent the movement of customers from the source (representing non-customers) on the left-hand side of the diagram, through the categories for multi-party customers (NRMP) and single-party customers (NRSP). The symbols with crossed lines superimposed on the larger arrows represent the controls for customer movement into or out of these categories. Thus, customers can enter the NRMP category through the control for the rate of multi-party customers entering (RMPE). Similarly, there are two possible paths by which customers can leave the multi-party category: through the

FIGURE 2

CUSTOMER SECTOR

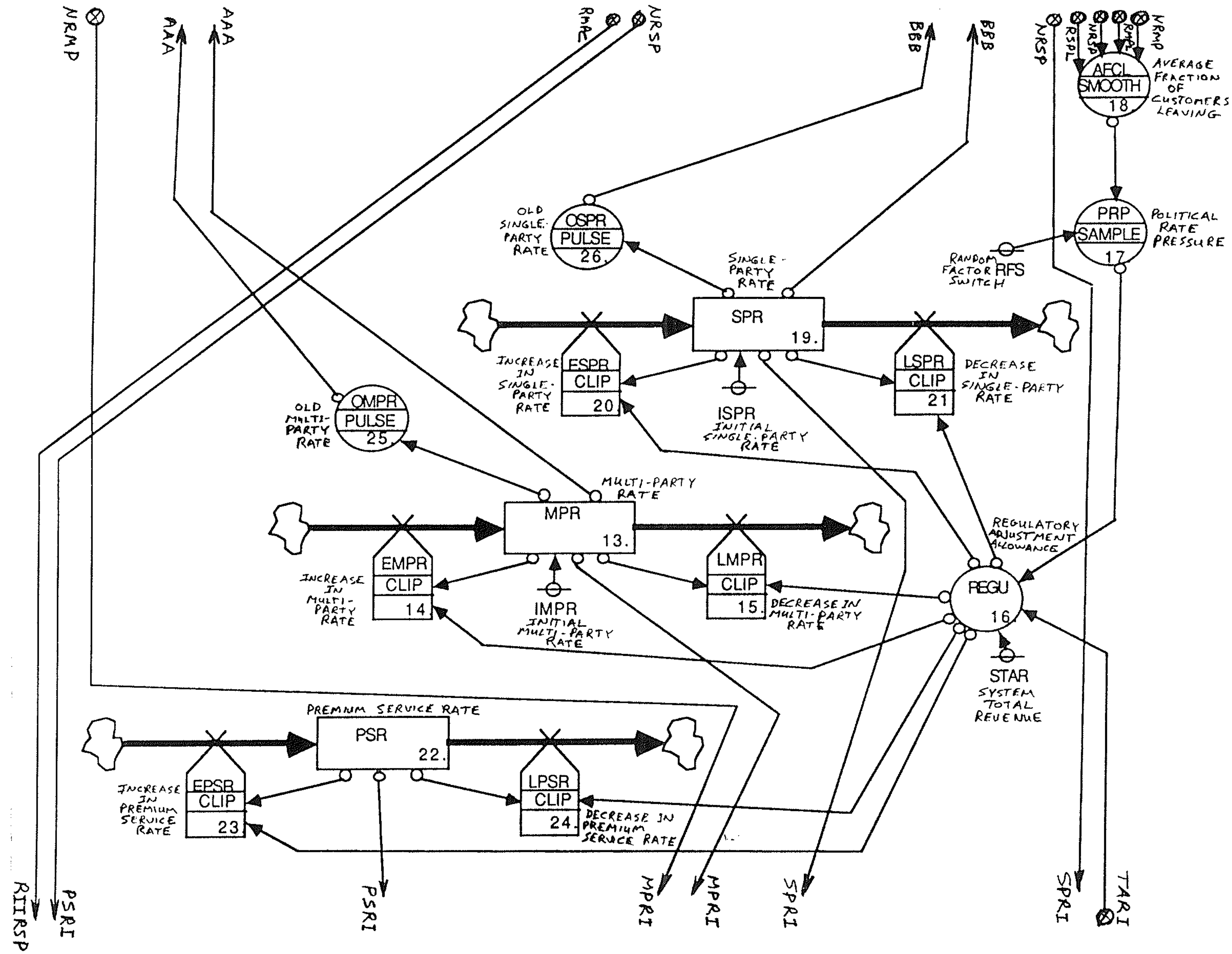


control for the rate of multi-party customers leaving (RMPL) to the sink of former customers, or through the control for rate of multi-party customers converting (RMPC) to become single-party customers in the NRSP category. A closer look at the operation of the RMPC control aids in the further understanding of such movements. RMPC depends on a number of factors; for example, functions (shown in larger circles) for the premium service policy conversion rate (PSCP) and for the number converted under the universal program (NCUP), and constants (shown as smaller, bisected circles) for the time of start of the universal program (TSUP) and for the years to complete the universal program (USPY). Further details concerning the functions and equations which have been used to model such movements for the Customer Sector are contained in Chapter 3. One aspect of the diagram which has not yet been discussed is the smaller arrows. These lines represent information flows; for example, the function for the multi-party limit switch (MPLS) takes information from NRMP concerning how many customers are in this category. If the number drops to zero, MPLS sends information to the controls RMPL and RMPC to stop any additional customer movement out of NRMP (since this category is empty). Small arrows, such as these, extending to the edge of the diagram, indicate interrelationships with other subsystems in the model. Arrowheads, or arrow tails, are shown with a label to indicate which particular function in another subsystem the information flows to, or from, respectively.

The Rates and Regulation Sector (Figure 3) represents: (1) the dollar amounts of the relevant monthly rates that the customers are charged for the various services,

FIGURE 3

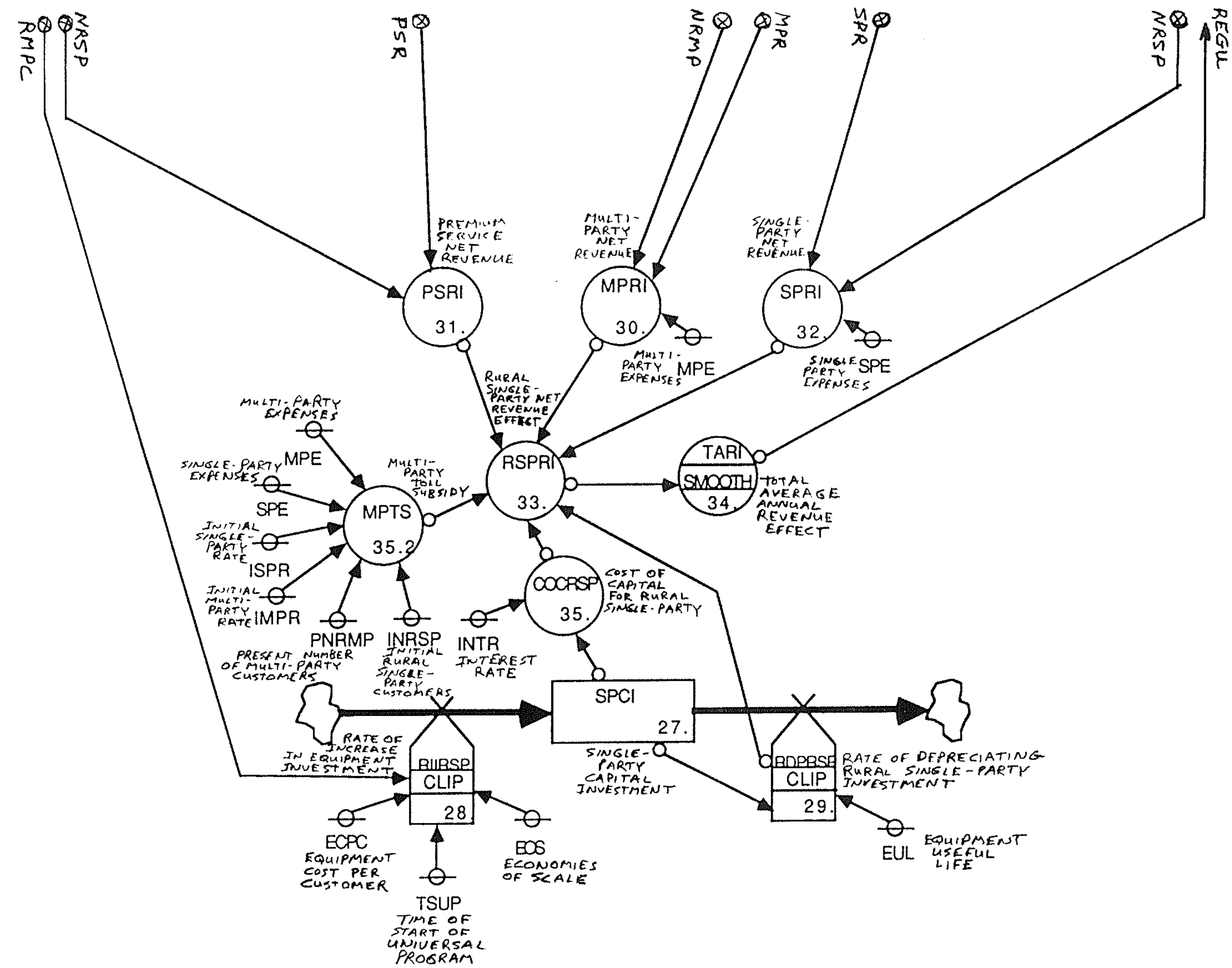
RATES & REGULATION SECTOR



and (2) the process of regulation of these rates by the Manitoba Public Utilities Board. The focus of this sector is on the three categories (shown as rectangles in Figure 3) representing the rates that customers are charged: Single-Party Rates (SPR), Multi-Party Rates (MPR), and Premium Service Rates (PSR). Each of these categories has a similar model structure - a control that regulates the movements into this category (large arrow in), representing rate increases, and a control that regulates the movements out of this category (large arrow out), representing rate decreases. The critical factor regulating these rate controls is the information from the regulatory adjustment allowance (REGU) function (shown as a larger circle). The inputs to this function are provided by the political rate pressure (PRP) function and the total average annual revenue effect (TARI) function in the Financial Sector, as well as the constant representing system total revenue (STAR - shown as a smaller, bisected circle). The PRP function takes an averaged view (average fraction of customers leaving (AFCL) function) of the percentage of customers leaving the network (using information from the Customer Sector), and combines this with a random factor - which represents the changes in political leadership over time. Other functions in this sector provide delayed versions of the rate categories (old single-party rate (OSPR) and old multi-party rate (OMPR)). Information from the current rates and the old rates is used in the Customer Sector to calculate the periodic percentage increase in rates. Details of the functions and equations which have been used to model the Rates and Regulation Sector are contained in Chapter 4.

FIGURE 4

<u>FINANCIAL SECTOR</u>



The Financial Sector (Figure 4) models: (1) the capital investment required for conversion to single-party service, and (2) the total average annual revenue effect of the program on the Manitoba Telephone System. The focus of this sector is the category that represents the accumulated capital investment for the single-party conversion program (SPCI). The control which lets capital dollars be added to SPCI - the rate of increase in equipment investment (RIIRSP), takes information from three constants: equipment cost per customer (ECPC), time of start of universal program (TSUP), and economies of scale (EOS), as well as the number of multi-party customers being converted to single-party service (RMPC) from the Customer Sector. The equations and assumptions used for this control, as well as other functions in the Financial Sector are discussed in detail in Chapter 5. Returning to the SPCI category, the number of dollars in this category is reduced by the depreciation of the equipment - modelled by the control for the rate of depreciating rural single party investment (RDPRSP).

Another focal point in this sector is the function for rural single-party net revenue effect (RSPRI), which collects the information concerning the financial impact of the various parts of the model. For example, the function for multi-party net revenue (MPRI) takes information about the number of multi-party customers from the Customer Sector, and information about the amount of multi-party rates from the Rates and Regulation Sector, and combines this information with the constant for multi-party expenses (MPE). The MPRI function then calculates the net revenue effect from all these multi-party factors, and sends the information to RSPRI for summation into the system total. The revenue effects are calculated similarly for the single-party and premium service factors, and forwarded to RSPRI for summation. Another important information input to RSPRI is the cost of the money that has been invested in the single-party conversion program (COCRSP). This function uses the amount of the capital investment (SPCI) and the interest rate (INTR) to calculate the cost of capital. Another input to RSPRI is the multi-party toll subsidy (MPTS). This function takes the initial values of respective rates, expenses and numbers of customers for single- and multi-party, and calculates the amount by which toll revenues subsidize these aspects of rural service. This information is sent to RSPRI for summation. The function for total average annual revenue effect (TARI) produces a delayed version of RSPRI, which is used by the regulatory adjustment allowance (REGU) function in the Rates and Regulation Sector.

The system model that is diagramatically displayed in the system flow diagrams (Figures 1-4) is described in more detail beginning in the next chapter.

TABLE 1

ALPHABETICAL LIST OF DEFINITION OF VARIABLES USED IN THE MODEL

NAME	NO	T	DEFINITION	WHERE USED
AAA	7	A	(1) RATE INCREASE "IRRITATION QUOTIENT"	RMPL,R,3
AFCL	18	A	(1/YEAR) AVERAGE FRACTION OF CUSTOMERS LEAVING	PRP,A,17
BBB	12	A	(1) SINGLE-PARTY RATE INCREASE "IRRITATION QUOTIENT"	RSPL,R,10
COCRSP	35	A	($/YEAR) COST OF CAPITAL FOR RURAL SINGLE-PARTY	RSPRI,A,33
DT	36.6	C		NRMP,L,1/NCUP,L,6/NRSP,L,9/MPR,L,13/SPR,L,19/PSR,L,22/OMPR,L,25/OSPR,L,26/SPCI,L,27
ECPC	27.2	C	($/CUSTOMERS) EQUIPMENT COST PER CUSTOMER	SPCI,N,27.1/RIIRSP,R,28
EMPR	14	R	($/CUSTOMER/YEAR/YEAR) INCREASE IN MULTI-PARTY RATE	MPR,L,13
EOS	28.1	C	(1) ECONOMIES OF SCALE	RIIRSP,R,28
EPSR	23	R	($/CUSTOMER/YEAR/YEAR) INCREASE IN PREMIUM SERVICE RATE	PSR,L,22
ESPR	20	R	($/CUSTOMER/YEAR/YEAR) INCREASE IN SINGLE-PARTY RATE	SPR,L,19
EUL	29.1	C	(YEAR) EQUIPMENT USEFUL LIFE	RDPRSP,R,29
IMPR	13.2	C	($/CUSTOMER/YEAR) INITIAL MULTI-PARTY RATE	MPR,N,13.1/MPTS,N,35.2
INFR	7.1	C	(1) INCREASE THRESHOLD FOR REACTION	AAA,A,7/BBB,A,12
INRSP	9.2	C	(CUSTOMERS) INITIAL RURAL SINGLE-PARTY CUSTOMERS	NRSP,N,9.1/SPCI,N,27.1/MPTS,N,35.2
INTR	35.1	C	(1/YEAR) INTEREST RATE	COCRSP,A,35
ISPR	19.2	C	($/CUSTOMER/YEAR) INITIAL SINGLE-PARTY RATE	SPR,N,19.1/MPTS,N,35.2
LENGTH	36.7	C		
LMPR	15	R	($/CUSTOMER/YEAR/YEAR) DECREASE IN MULTI-PARTY RATE	MPR,L,13
LPSR	24	R	($/CUSTOMER/YEAR/YEAR) DECREASE IN PREMIUM SERVICE RATE	PSR,L,22
LSPR	21	R	($/CUSTOMER/YEAR/YEAR) DECREASE IN SINGLE-PARTY RATE	SPR,L,19
MPE	30.1	C	($/CUSTOMER/YEAR) MULTI-PARTY EXPENSES	MPRI,A,30/MPTS,N,35.2
MPG	2.1	C	(1/YEAR) FRACTION GROWTH OF MANITOBA POPULATION	RMPE,R,2
MPLS	4	A	(1) MULTI-PARTY LIMIT SWITCH	RMPL,R,3/RMPC,R,5
MPR	13 13.1	L N	($/CUSTOMER/YEAR) MULTI-PARTY RATE	AAA,A,7/EMPR,R,14/LMPR,R,15/OMPR,L,25/OMPR,N,25.1/MPRI,A,30
MPRI	30	A	($/YEAR) MULTI-PARTY NET REVENUE	RSPRI,A,33
MPTS	35.2	N	($/YEAR) MULTI-PARTY TOLL SUBSIDY	RSPRI,A,33
NCUP	6 6.1	L N	(CUSTOMER) NUMBER CONVERTED UNDER UNIVERSAL PROGRAM	RMPC,R,5
NRMP	1 1.1	L N	(CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS	RMPE,R,2/RMPL,R,3/MPLS,A,4/NCUP,L,6/AFCL,A,18/MPRI,A,30
NRSP	9 9.1	L N	(CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS	RSPL,R,10/SPLS,A,11/AFCL,A,18/PSRI,A,31/SPRI,A,32
OMPR	25 25.1	L N	($/CUSTOMER/YEAR) OLD MULTI-PARTY RATE	AAA,A,7

TABLE 1 (continued)

ALPHABETICAL LIST OF DEFINITION OF VARIABLES USED IN THE MODEL (CONT'D)

OSPR	26 26.1	L N	($/CUSTOMER/YEAR) OLD SINGLE-PARTY RATE	BBB,A,12
PLTPER	36.4	C		
PNRMP	1.2	C	(CUSTOMERS) PRESENT NUMBER OF MULTI-PARTY CUSTOMERS	NRMP,N,1.1/MPTS,N,35.2
PRP	17	A	(1/YEAR) POLITICAL RATE PRESSURE	REGU,A,16
PRTPER	36.3	C		
PSCC	8.2	C	($) PREMIUM SERVICE CUSTOMER CHARGE	PSCP,A,8
PSCP	8	A	(CUSTOMERS/YEAR) PREMIUM SERVICE POLICY CONVERSION RATE	RMPC,R,5
PSCPTA	8.1	T	(CUSTOMERS/YEAR) PREMIUM SERVICE POLICY CONVERSION RATE TABLE	PSCP,A,8
PSR	22 22.1	L N	($/CUSTOMER/YEAR) PREMIUM SERVICE RATE	EPSR,R,23/LPSR,R,24/PSRI,A,31
PSRI	31	A	($/YEAR) PREMIUM SERVICE NET REVENUE	RSPRI,A,33
RDPRSP	29	R	($/YEAR) RATE OF DEPRECIATING RURAL SINGLE-PARTY INVESTMENT	SPCI,L,27/RSPRI,A,33
REGU	16	A	(1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE	EMPR,R,14/LMPR,R,15/ESPR,R,20/LSPR,R,21/EPSR,R,23/LPSR,R,24
RFS	17.1	C	(1) RANDOM FACTOR SWITCH	PRP,A,17
RIIRSP	28	R	($/YEAR) RATE OF INCREASE IN EQUIPMENT INVESTMENT	SPCI,L,27
RMPC	5	R	(CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING	NRMP,L,1/NRSP,L,9/RIIRSP,R,28
RMPE	2	R	(CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS ENTERING	NRMP,L,1
RMPL	3	R	(CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING	NRMP,L,1/AFCL,A,18
RMPLTA	3.1	T	(CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING TABLE	RMPL,R,3
RSPL	10	R	(CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING	NRSP,L,9/AFCL,A,18
RSPLTA	10.1	T	(CUSTOMERS/YEAR) TABLE FOR RSPL	RSPL,R,10
RSPRI	33	A	($/YEAR) RURAL SINGLE-PARTY NET REVENUE EFFECT	TARI,A,34
SAVPER	36.5	C		
SPCI	27 27.1	L N	($) SINGLE-PARTY CAPITAL INVESTMENT	RDPRSP,R,29/COCRSP,A,35
SPE	32.1	C	($/CUSTOMER/YEAR) SINGLE-PARTY EXPENSES	SPRI,A,32/MPTS,N,35.2
SPLS	11	A	(1) SINGLE-PARTY LIMIT SWITCH	RSPL,R,10
SPR	19 19.1	L N	($/CUSTOMER/YEAR) SINGLE-PARTY RATE	BBB,A,12/ESPR,R,20/LSPR,R,21/OSPR,L,26/OSPR,N,26.1/SPRI,A,32
SPRI	32	A	($/YEAR) SINGLE-PARTY NET REVENUE	RSPRI,A,33
STAR	16.1	C	($) SYSTEM TOTAL REVENUE	REGU,A,16
TARI	34	A	($/YEAR) TOTAL AVERAGE ANNUAL REVENUE EFFECT	REGU,A,16
TIME				RMPC,R,5/RIIRSP,R,28
TSUP	5.2	C	(YEAR) TIME OF START OF UNIVERSAL PROGRAM	RMPC,R,5/NCUP,L,6/RIIRSP,R,28
USPY	5.1	C	(YEAR) YEARS TO COMPLETE UNIVERSAL PROGRAM	RMPC,R,5

CHAPTER 3

CUSTOMER SECTOR

The customer sector of the model (see Figure 2) comprises a number of relationships involving the numbers of customers in various categories, moving into and out of these categories, and transferring from one category to another. The equations (refer to Table 2 for complete list) to represent these relationships (in DYNAMO form) are now presented and argued.

TABLE 2

LISTING OF DYNAMO EQUATIONS USED IN THE CUSTOMER SECTOR

```
NRMP.K=NRMP.J+DT*(RMPE.JK-RMPL.JK-RMPC.JK)                    1, L
NRMP=PNRMP                                                   1.1, N
PNRMP=46600                                                  1.2, C
    NRMP   - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS
    RMPE   - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS ENTERING
    RMPL   - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING
    RMPC   - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING
    PNRMP  - (CUSTOMERS) PRESENT NUMBER OF MULTI-PARTY CUSTOMERS
    DT     - (YEAR) SIMULATION TIME INTERVAL

RMPE.KL=NRMP.K*MPG                                           2, R
MPG=.0067                                                    2.1, C
    RMPE   - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS ENTERING
    NRMP   - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS
    MPG    - (1/YEAR) FRACTION GROWTH OF MANITOBA POPULATION

RMPL.KL=(TABHL(RMPLTA,AAA.K,-0.1,1.0,0.1))*NRMP.K*MPLS.K     3, R
RMPLTA=0/0/.005/.01/.015/.02/.025/.032/.042/.058/.078/.1     3.1, T
    RMPL   - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING
    RMPLTA - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING TABLE
    AAA    - (1) RATE INCREASE "IRRITATION QUOTIENT"
    NRMP   - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS
    MPLS   - (1) MULTI-PARTY LIMIT SWITCH
```

TABLE 2 (continued)

LISTING OF DYNAMO EQUATIONS USED IN THE CUSTOMER SECTOR

```
MPLS.K=CLIP(0,1,0,NRMP.K)                                   4, A
   MPLS   - (1) MULTI-PARTY LIMIT SWITCH
   NRMP   - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS

RMPC.KL=CLIP(PSCP.K,NCUP.K/USPY,TSUP,TIME.K)*MPLS.K         5, R
USPY=7                                                      5.1, C
TSUP=2                                                      5.2, C
   RMPC   - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING
   PSCP   - (CUSTOMERS/YEAR) PREMIUM SERVICE POLICY CONVERSION RATE
   NCUP   - (CUSTOMER)  NUMBER CONVERTED UNDER UNIVERSAL PROGRAM
   USPY   - (YEAR) YEARS TO COMPLETE UNIVERSAL PROGRAM
   TSUP   - (YEAR) TIME OF START OF UNIVERSAL PROGRAM
   MPLS   - (1) MULTI-PARTY LIMIT SWITCH

NCUP.K=NCUP.J+DT*PULSE(NRMP.J/DT,TSUP,1E6)                  6, L
NCUP=0                                                      6.1, N
   NCUP   - (CUSTOMER)  NUMBER CONVERTED UNDER UNIVERSAL PROGRAM
   NRMP   - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS
   TSUP   - (YEAR) TIME OF START OF UNIVERSAL PROGRAM

AAA.K=((MPR.K-OMPR.K)/OMPR.K)-INFR                          7, A
INFR=.03                                                    7.1, C
   AAA    - (1) RATE INCREASE "IRRITATION QUOTIENT"
   MPR    - ($/CUSTOMER/YEAR) MULTI-PARTY RATE
   OMPR   - ($/CUSTOMER/YEAR) OLD MULTI-PARTY RATE
   INFR   - (1) INCREASE THRESHOLD FOR REACTION

PSCP.K=TABHL(PSCPTA,PSCC,0,800,100)                         8, A
PSCPTA=2800/2000/1200/850/675/500/450/425/400               8.1, T
PSCC=515                                                    8.2, C
   PSCP   - (CUSTOMERS/YEAR) PREMIUM SERVICE POLICY CONVERSION RATE
   PSCPTA - (CUSTOMERS/YEAR) PREMIUM SERVICE POLICY CONVERSION RATE TABLE
   PSCC   - ($) PREMIUM SERVICE CUSTOMER CHARGE

NRSP.K=NRSP.J+DT*(RMPC.JK-RSPL.JK)                          9, L
NRSP=INRSP                                                  9.1, N
INRSP=2500                                                  9.2, C
   NRSP   - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS
   RMPC   - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING
   RSPL   - (CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING
   INRSP  - (CUSTOMERS) INITIAL RURAL SINGLE-PARTY CUSTOMERS

RSPL.KL=(TABHL(RSPLTA,BBB.K,-0.1,1.0,0.1))*NRSP.K*SPLS.K    10, R
RSPLTA=0/0/.005/.01/.015/.02/.025/.032/.042/.058/.078/.1    10.1, T
   RSPL   - (CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING
   RSPLTA - (CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING TABLE
   BBB    - (1) SINGLE-PARTY RATE INCREASE "IRRITATION QUOTIENT"
   NRSP   - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS
   SPLS   - (1) SINGLE-PARTY LIMIT SWITCH

SPLS.K=CLIP(0,1,0,NRSP.K)                                   11, A
   SPLS   - (1) SINGLE-PARTY LIMIT SWITCH
   NRSP   - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS

BBB.K=((SPR.K-OSPR.K)/OSPR.K)-INFR                          12, A
   BBB    - (1) SINGLE-PARTY RATE INCREASE "IRRITATION QUOTIENT"
   SPR    - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE
   OSPR   - ($/CUSTOMER/YEAR) OLD SINGLE-PARTY RATE
   INFR   - (1) INCREASE THRESHOLD FOR REACTION
```

3.1 NUMBER OF MULTI-PARTY CUSTOMERS

NRMP.K=NRMP.J+DT*(RMPE.JK-RMPL.JK-RMPC.JK) 1,L

NRMP=PNRMP

PNRMP=46600

NRMP - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS

RMPE - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS ENTERING

RMPL - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING

RMPC - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING

PNRMP - (CUSTOMERS) PRESENT NUMBER OF MULTI-PARTY CUSTOMERS

This level equation represents the current number of rural multi-party customers and is central to the behaviour of the entire model system. It integrates the rates of movement of customers into and out of the category of multi-party customers (i.e., the current number of multi-party customers (NRMP) equals the previous number of these customers, plus the rate of multi-party customers entering (RMPE), minus the rate of multi-party customers leaving (RMPL), minus the rate of customers converting to single-party service (RMPC), integrated over the time interval DT). These controls represent the movement into and out of the NRMP category. RMPE is the control for the rate of multi-party customers entering the network from the source of non-customers. RMPL is the control for the rate of multi-party customers leaving the network. RMPC represents the control for the number of multi-party customers converting to single-party customers. PNRMP is the initial number of multi-party customers, at the start of the simulation. This number (PNRMP) is derived from MTS sources (MTS 1988).

3.2 RATE OF MULTI-PARTY CUSTOMERS ENTERING

RMPE.KL=NRMP.K*MPG 2,R

MPG=.0067

RMPE - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS ENTERING

NRMP - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS

MPG - (1/YEAR) FRACTION GROWTH OF MANITOBA POPULATION

This equation shows the growth in the number of multi-party customers. The simplifying assumption is made that the percentage growth in rural population in Manitoba is the same as the average population growth rate forecast for the province of Manitoba (MPG) (forecast based on 1987 and 1988 population growth - Statistics Canada 1988). The growth in the number of multi-party customers is a product of the previous period number of multi-party customers (NRMP.K) and the Manitoba population growth rate (MPG). This is felt to be a reasonable estimate of the actual growth in the number of multi-party customers, as this growth depends upon the gross area wherein multi-party service is the standard service offering, and the overall growth in population. One objection to this approach is that the growth in rural areas does not necessarily match average growth for Manitoba. The model, however, can easily be changed to simulate higher or lower growth rates in the areas where multi-party service is offered.

3.3 RATE OF MULTI-PARTY CUSTOMERS LEAVING

RMPL.KL=(TABHL(RMPLTA,AAA.K,-0.1,1.0,0.1))*NRMP.K*MPLS.K 3,R

RMPLTA=0/0/.005/.01/.015/.02/.025/.032/.042/.058/.078/.1

MPLS.K=CLIP(0,1,0,NRMP.K)

RMPL - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING

RMPLTA - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING TABLE

AAA - (1) RATE INCREASE IRRITATION QUOTIENT

MPLS - (1) MULTI-PARTY LIMIT SWITCH

NRMP - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS

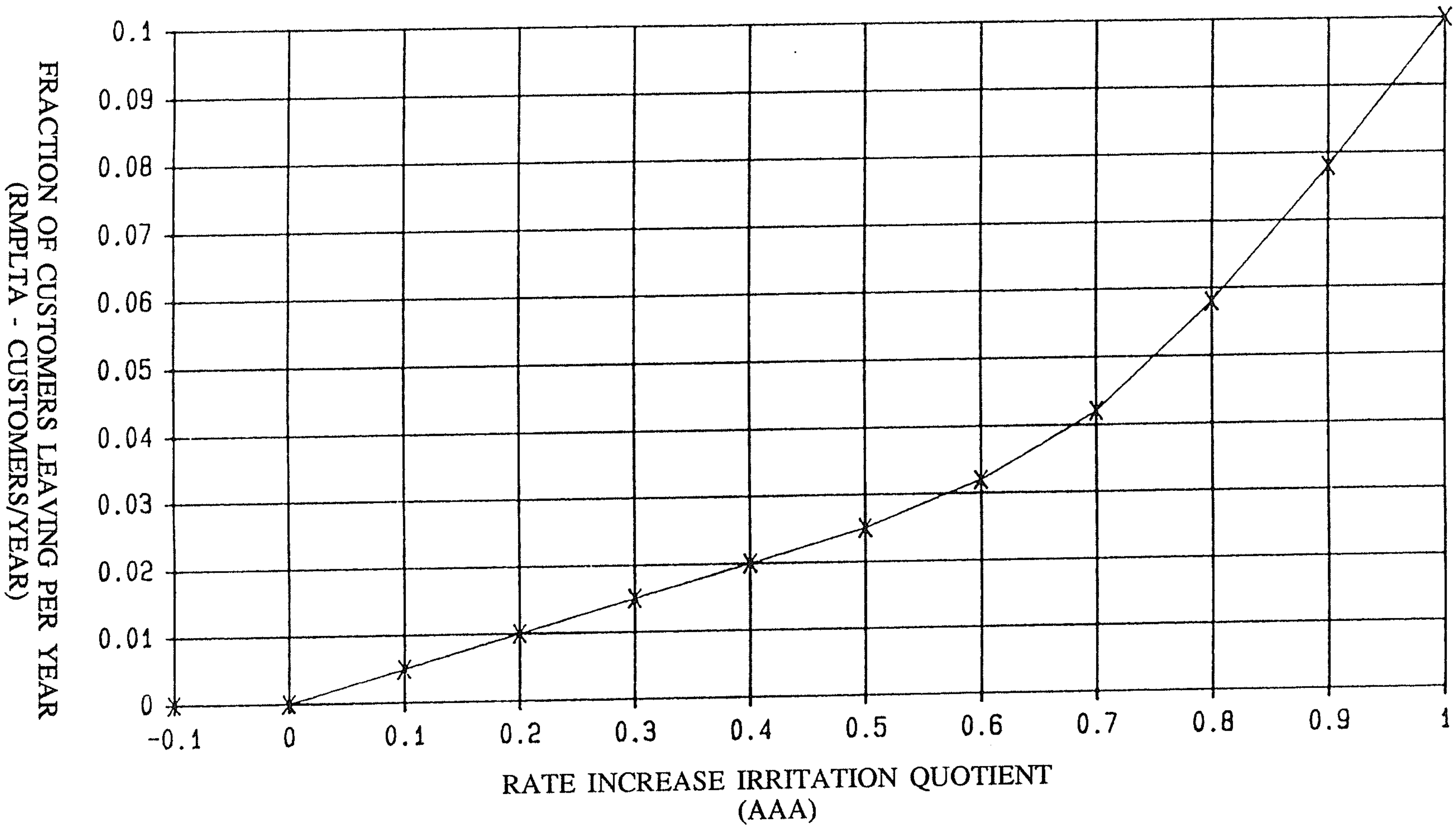
One of the factors that decreases the number of multi-party customers is the number of these customers that leave the network (RMPL). The majority of customers leaving the network do so because of moving, billing problems, service dissatisfaction or other factors not directly related to the cost of service

(Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986). For this model, however, the relevant motivation for leaving the network is related to price sensitivity, or more specifically, to price increase sensitivity. This factor is modeled by constructing a table (graphically depicted in Figure 5) that responds to a variable representing the customer irritation with price increases (AAA - defined in Section 3.6). In the first equation (which determines RMPL.KL), this table is implemented by the DYNAMO function "TABHL". A limit switch (MPLS) is used to ensure that the number of customers cannot be reduced below zero. The CLIP function used in the MPLS.K equation produces a value of 1 for positive values of NRMP.K, and 0 for non-positive values.

The rate of multi-party customers leaving table (RMPLTA) equation uses the values shown in Figure 5 to identify the fraction of customers leaving the network in relation to the value of the irritation variable (AAA - defined in Section 3.6). In simple terms, the more that telephone rates increase faster than the threshold rate, the more customers will elect to leave the network. Studies of rapidly increasing local telephone service rates after industry deregulation in the United States have demonstrated that the demand elasticity for telephone access is very small (Park and Mitchell 1987). This price elasticity has been decreasing with higher telephone penetration levels, and the growing perception of telephone service as a necessity. Two other factors that reduce the potential impact of price increases are the small proportion of household disposable income being allocated to telephone expenses (0.28% in Winnipeg in 1984, and may be slightly higher or

FIGURE 5

RATE OF MULTI-PARTY CUSTOMERS LEAVING



lower in rural areas) and the established trend of telephone rates increasing much more slowly than the Consumer Price Index. The values presented in the RMPLTA table are derived from estimates of the price elasticity of residential demand for local telephone service in Canada. For example, if the rates doubled within one year, the value of AAA (see Section 3.6) would be .97, and the fraction of customers leaving per year would be slightly less than .1 (Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986).

<u>3.4 RATE OF MULTI-PARTY CUSTOMERS CONVERTING</u>

RMPC.KL=CLIP(PSCP.K,NCUP.K/USPY,TSUP,TIME.K)*MPLS.K 5,R

USPY=7

TSUP=2

RMPC - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING

PSCP - (CUSTOMERS/YEAR) PREMIUM SERVICE POLICY CONVERSION RATE

NCUP - (CUSTOMERS) NUMBER CONVERTED UNDER UNIVERSAL PROGRAM

USPY - (YEAR) YEARS TO COMPLETE UNIVERSAL PROGRAM

TSUP - (YEAR) TIME OF START OF UNIVERSAL PROGRAM

MPLS - (1) MULTI-PARTY LIMIT SWITCH

This equation represents the number of multi-party customers converting to single-party service (RMPC), and thus no longer being multi-party customers. There are two possible major variables that govern this rate: premium service policy conversion rate (PSCP), and the number converted under the universal program (NCUP). PSCP represents the expected number of conversions per year due to a premium service program, such as the existing program. NCUP (see Section 3.5) represents the number converting per year under a universal single-party conversion policy. The time of the start of the universal program (TSUP) is the point in time that the single-party conversion program switches from premium service to universal (MTS 1988). This arrangement allows experiments to be run with universal programs beginning at various future dates. The equation also contains a limit switch (MPLS) to avoid reducing the number of multi-party customers below zero.

3.5 NUMBER TO BE CONVERTED UNDER UNIVERSAL PROGRAM

NCUP.K=NCUP.J+DT*PULSE(NRMP.J/DT,TSUP,1E6) 6,L

NCUP=0

NCUP - (CUSTOMERS) NUMBER CONVERTED UNDER UNIVERSAL PROGRAM

TSUP - (YEAR) TIME OF START OF UNIVERSAL PROGRAM

NRMP - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS

The level equation for the number converted under the universal program (NCUP) is initially set to zero, and remains at zero until the time that a universal conversion program is initiated (TSUP). The PULSE function, which is in effect only at time TSUP, then increments NCUP by the number of multi-party customers (NRMP) at that time. Thus, NCUP is set to NRMP at time TSUP, since all remaining multi-party customers are to be converted to single-party service by a universal program. The level thereby established for NCUP remains for the duration of the simulation. Although the actual number converted will vary from year to year according to the specific locations being converted, a single number for NCUP is a realistic modeling assumption since the planning goal for each year will average NCUP divided by the number of years to complete the universal program (USPY) for the duration of the program. Should more multi-party customers join the network during the universal program, the target time (TSUP + USPY) for completion of the program will be exceeded. Since the growth in the number of multi-party customers is proportionately so small, this situation will have only a marginal effect on the simulation results. This represents a view of the management of major programs that is evident in planning many such programs. For example, the French experience with Videotex includes free distribution of Minitel terminals to subscribers. The target of one Minitel terminal per three main telephone lines in France by 1990 is being addressed by scheduling the installation of 1.5 million Minitel terminals per year (Fourier and Carrie 1987). Thus, for a universal program in Manitoba, a target of approximately NCUP/USPY conversions per year is expected.

3.6 MULTI-PARTY IRRITATION QUOTIENT

AAA.K=((MPR.K-OMPR.K)/OMPR.K)-INFR 7,A

INFR=.03

AAA - (1) RATE INCREASE IRRITATION QUOTIENT

MPR - ($/CUSTOMER/YEAR) MULTI-PARTY RATE

OMPR - ($/CUSTOMER/YEAR) OLD MULTI-PARTY RATE

INFR - (1) INCREASE THRESHOLD FOR REACTION

This equation constructs the variable that models customer irritation with price increases (AAA). This is simply the relative increase in price with respect to the old multi-party rate (OMPR), with the increase threshold for reaction (INFR) subtracted. The threshold rate is based on the assumption that customers will not notice, or will at least tolerate, a three percent real price increase without being irritated enough to begin dropping off the network (McKinsey 1988).

3.7 PREMIUM SERVICE CONVERSION RATE

PSCP.K=TABHL(PSCPTA,PSCC,0,800,100) 8,A

PSCPTA=2800/2000/1200/850/675/500/450/425/400

PSCC=515

PSCP - (CUSTOMERS/YEAR) PREMIUM SERVICE POLICY CONVERSION RATE

PSCPTA - (CUSTOMERS/YEAR) PREMIUM SERVICE POLICY CONVERSION RATE TABLE

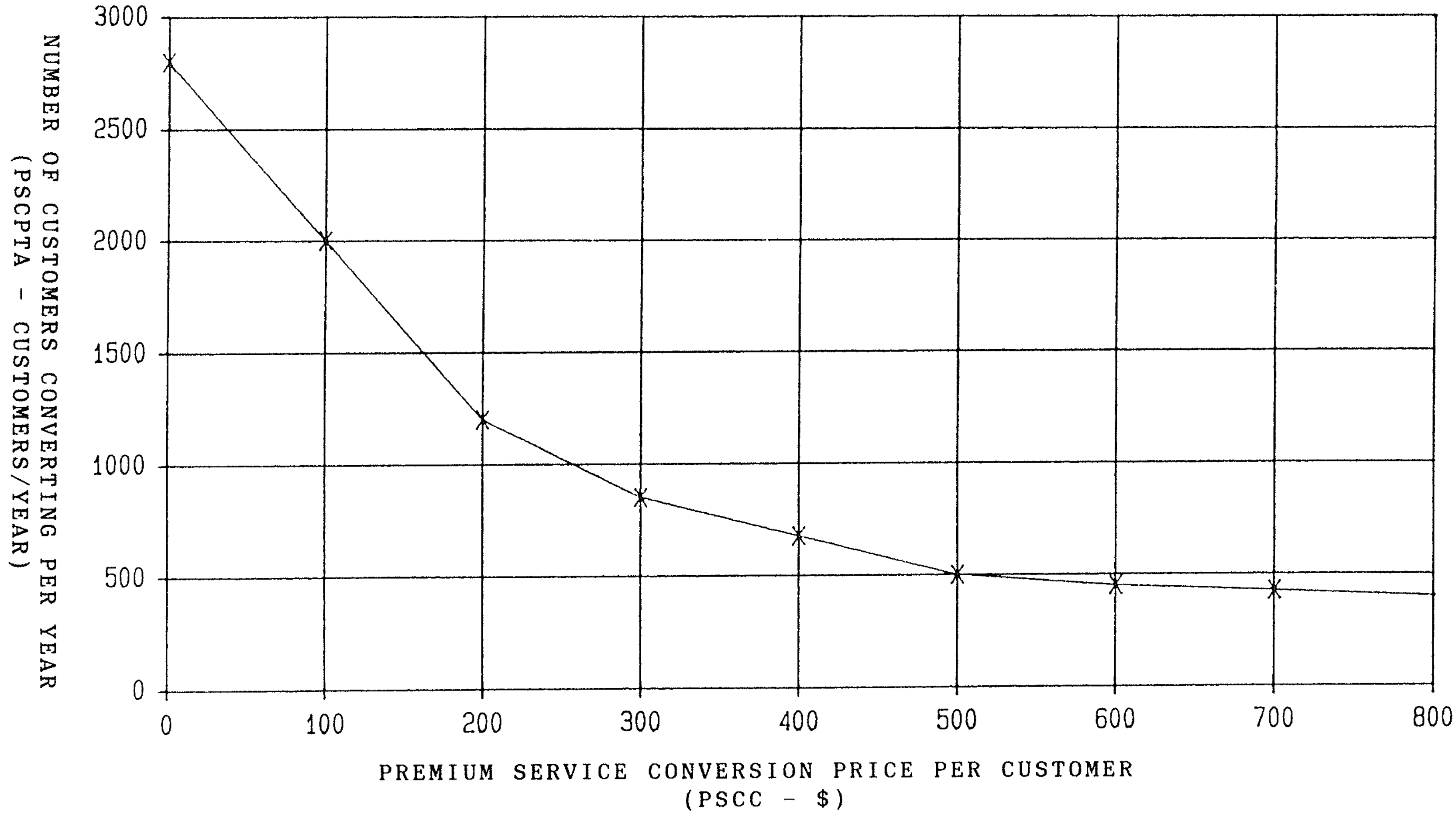
PSCC - ($) PREMIUM SERVICE CUSTOMER CHARGE

This equation uses a table (PSCPTA) to estimate the number of customers who would choose to convert from multi-party service to single-party service during each period (premium service policy conversion rate - PSCP), according to the amount of the premium service customer charge (PSCC). This program had been in operation for a number of years at MTS, so there has been some historic validity analysis possible at the $500 charge level, using MTS premium service customer information (MTS 1987a). Prior to 1982, this conversion was available for actual construction costs (generally higher than $500), so that the slope of the curve (shown in Figure 6) for PSCC charge levels above $500 has been determined from the pre-1982 conversion history (MTS 1987a). A market research report (Criterion 1987) has provided the basis for estimating the values for PSCC at the lower charge levels between $0 and $500.

The table shown in Figure 6 is based upon this information. Beyond the range presented in this table, values cannot be supported within reasonable levels of confidence. The extension of the upper values for inputs outside the range of the table is therefore estimated to remain at the level shown for PSCC of $800, based on the convergence noted in the curve.

FIGURE 6

PREMIUM SERVICE POLICY CONVERSION RATE TABLE



3.8 POOL OF SINGLE-PARTY CUSTOMERS

NRSP.K=NRSP.J+DT*(RMPC.JK-RSPL.JK) 9,L

NRSP=INRSP

INRSP=2500

NRSP - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS

RMPC - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING

RSPL - (CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING

INRSP - (CUSTOMERS) INITIAL RURAL SINGLE-PARTY CUSTOMERS

This level equation of the number of rural single-party customers (NRSP) that have been converted from multi-party service (equation #1) integrates the movements of customers into and out of this category. The rate of multi-party customers converting (RMPC) represents the number of multi-party customers converting to single-party customers. The rate of single-party customers leaving (RSPL) is the rate of new single-party customers leaving the network. These rates represent the movement of customers into and out of the category of rural single-party customers. Since the marginal effects of multi- to single-party conversion strategies are being evaluated, only the single-party customers that have converted from multi-party service are considered in this model. The initial number of such new single-party customers (INRSP) is based upon information about present MTS premium service customers (MTS 1987a).

3.9 RATE OF SINGLE-PARTY CUSTOMERS LEAVING

RSPL.KL=(TABHL(RSPLTA,BBB.K,-0.1,1.0,0.1))*NRSP.K*SPLS.K 10,R

RSPLTA=0/0/.005/.01/.015/.02/.025/.032/.042/.058/.078/.1

SPLS.K=CLIP(0,1,0,NRSP.K) 11,A

RSPL - (CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING

RSPLTA - (CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING TABLE

BBB - (1) SINGLE-PARTY RATE INCREASE IRRITATION QUOTIENT

SPLS - (1) SINGLE-PARTY LIMIT SWITCH

NRSP - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS

One of the factors that decreases the number of single-party customers (analogous to the previous discussion of multi-party customers - Section 3.3) is the number of these customers that leave the network. This factor is modeled for single-party customers by constructing a table (graphically depicted in Figure 7) that responds to a variable (BBB - defined in Section 3.10) representing the customer irritation with price increases. A limit switch (SPLS) is used to ensure that the number of customers cannot be reduced below zero. The operation of SPLS is analogous to MPLS (described in Section 3.3).

The table shown in Figure 7 identifies the response of single-party customers leaving the network in relation to the value of the irritation variable (BBB -

defined in Section 3.10). The assumptions and operations of this set of equations and this table is analogous to those described for multi-party customers in Section 3.3.

3.10 SINGLE-PARTY IRRITATION QUOTIENT

BBB.K=((SPR.K-OSPR.K)/OSPR.K)-INFR   12,A

BBB - (1) SINGLE-PARTY RATE INCREASE IRRITATION QUOTIENT

SPR - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE

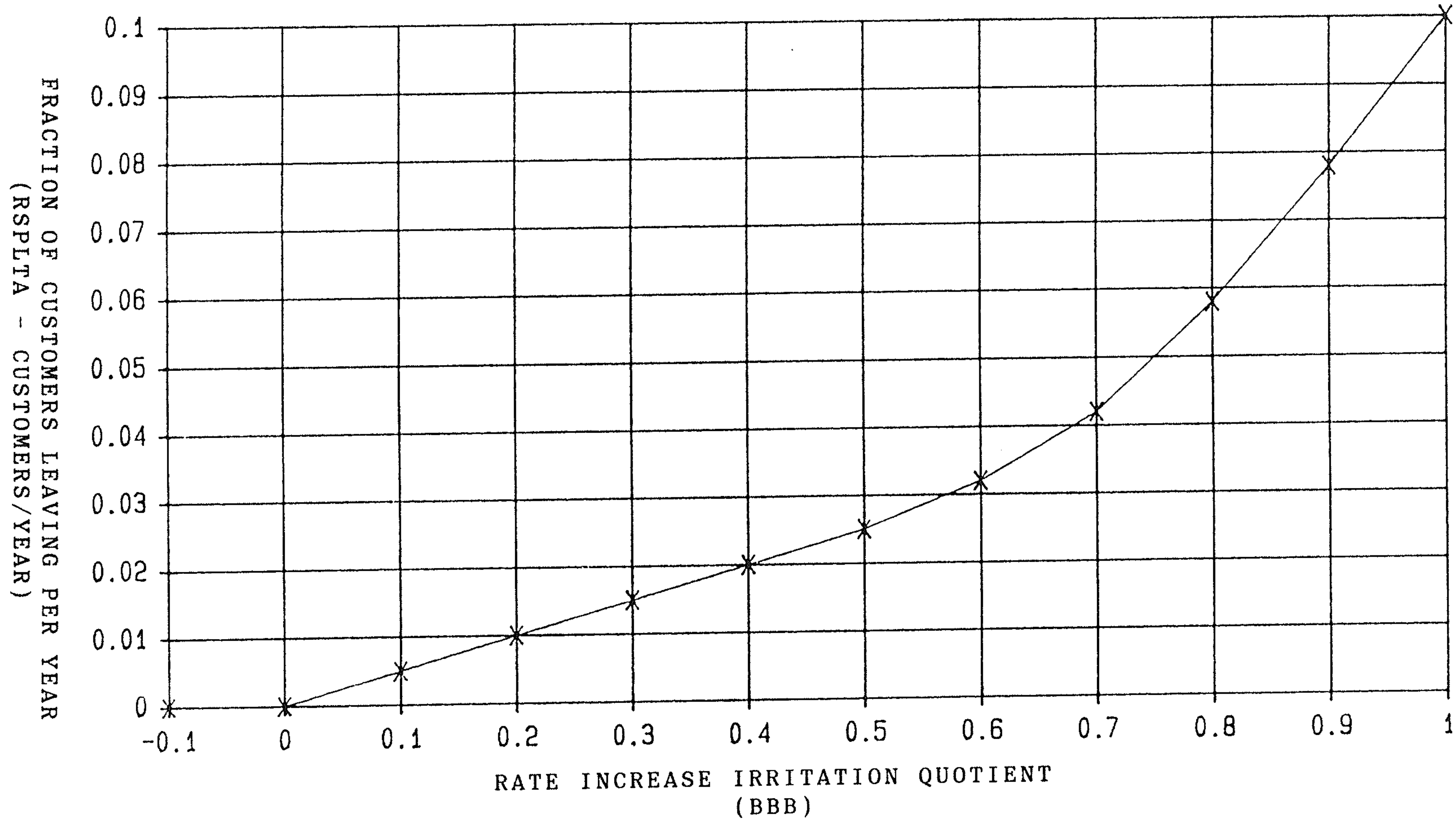
OSPR - ($/CUSTOMER/YEAR) OLD SINGLE-PARTY RATE

INFR - (1) INCREASE THRESHOLD FOR REACTION

This equation constructs the variable (BBB) that models single-party customer irritation with price increases. The operation of this equation is analogous to that of AAA, described in Section 3.6.

FIGURE 7

RATE OF SINGLE-PARTY CUSTOMERS LEAVING TABLE



CHAPTER 4

RATES AND REGULATION SECTOR

The rates and regulation sector (see Figure 3) is the part of the model that contains relationships between the rates charged for different services, the process of changing these rates, and the political and regulatory pressures on them. The assumptions and representative DYNAMO equations are now presented in detail.

TABLE 3

LISTING OF DYNAMO EQUATIONS USED IN THE RATES AND REGULATION SECTOR

```
MPR.K=MPR.J+DT*(EMPR.JK-LMPR.JK)                                13, L
MPR=IMPR                                                        13.1, N
IMPR=72.42                                                      13.2, C
   MPR   - ($/CUSTOMER/YEAR) MULTI-PARTY RATE
   EMPR  - ($/CUSTOMER/YEAR/YEAR) INCREASE IN MULTI-PARTY RATE
   LMPR  - ($/CUSTOMER/YEAR/YEAR) DECREASE IN MULTI-PARTY RATE
   IMPR  - ($/CUSTOMER/YEAR) INITIAL MULTI-PARTY RATE

EMPR.KL=CLIP(MPR.K*REGU.K,0,REGU.K,0)                           14, R
   EMPR  - ($/CUSTOMER/YEAR/YEAR) INCREASE IN MULTI-PARTY RATE
   MPR   - ($/CUSTOMER/YEAR) MULTI-PARTY RATE
   REGU  - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

LMPR.KL=CLIP(0,MPR.K*REGU.K,REGU.K,0)                           15, R
   LMPR  - ($/CUSTOMER/YEAR/YEAR) DECREASE IN MULTI-PARTY RATE
   MPR   - ($/CUSTOMER/YEAR) MULTI-PARTY RATE
   REGU  - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

REGU.K=-(TARI.K/STAR)-PRP.K                                     16, A
STAR=3.7687E8                                                   16.1,
   REGU  - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE
   TARI  - ($/YEAR) TOTAL AVERAGE ANNUAL REVENUE EFFECT
   STAR  - ($) SYSTEM TOTAL REVENUE
   PRP   - (1/YEAR) POLITICAL RATE PRESSURE
```

TABLE 3 (continued)

LISTING OF DYNAMO EQUATIONS USED IN THE RATES AND REGULATION SECTOR

```
PRP.K=AFCL.K*SAMPLE(((NOISE()+.5)*RFS),4,0)                    17, A
RFS=0                                                          17.1, C
    PRP   - (1/YEAR) POLITICAL RATE PRESSURE
    AFCL  - (1/YEAR) AVERAGE FRACTION OF CUSTOMERS LEAVING
    RFS   - (1) RANDOM FACTOR SWITCH

AFCL.K=SMOOTH(((RMPL.JK+RSPL.JK)/(NRMP.K+NRSP.K)),1)           18, A
    AFCL  - (1/YEAR) AVERAGE FRACTION OF CUSTOMERS LEAVING
    RMPL  - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING
    RSPL  - (CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING
    NRMP  - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS
    NRSP  - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS

SPR.K=SPR.J+DT*(ESPR.JK-LSPR.JK)                               19, L
SPR=ISPR                                                       19.1, N
ISPR=95.22                                                     19.2, C
    SPR   - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE
    ESPR  - ($/CUSTOMER/YEAR/YEAR) INCREASE IN SINGLE-PARTY RATE
    LSPR  - ($/CUSTOMER/YEAR/YEAR) DECREASE IN SINGLE-PARTY RATE
    ISPR  - ($/CUSTOMER/YEAR) INITIAL SINGLE-PARTY RATE

ESPR.KL=CLIP(SPR.K*REGU.K,0,REGU.K,0)                          20, R
    ESPR  - ($/CUSTOMER/YEAR/YEAR) INCREASE IN SINGLE-PARTY RATE
    SPR   - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE
    REGU  - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

LSPR.KL=CLIP(0,SPR.K*REGU.K,REGU.K,0)                          21, R
    LSPR  - ($/CUSTOMER/YEAR/YEAR) DECREASE IN SINGLE-PARTY RATE
    SPR   - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE
    REGU  - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

PSR.K=PSR.J+DT*(EPSR.JK-LPSR.JK)                               22, L
PSR=37.2                                                       22.1, N
    PSR   - ($/CUSTOMER/YEAR) PREMIUM SERVICE RATE
    EPSR  - ($/CUSTOMER/YEAR/YEAR) INCREASE IN PREMIUM SERVICE RATE
    LPSR  - ($/CUSTOMER/YEAR/YEAR) DECREASE IN PREMIUM SERVICE RATE

EPSR.KL=CLIP(PSR.K*REGU.K,0,REGU.K,0)                          23, R
    EPSR  - ($/CUSTOMER/YEAR/YEAR) INCREASE IN PREMIUM SERVICE RATE
    PSR   - ($/CUSTOMER/YEAR) PREMIUM SERVICE RATE
    REGU  - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

LPSR.KL=CLIP(0,PSR.K*REGU.K,REGU.K,0)                          24, R
    LPSR  - ($/CUSTOMER/YEAR/YEAR) DECREASE IN PREMIUM SERVICE RATE
    PSR   - ($/CUSTOMER/YEAR) PREMIUM SERVICE RATE
    REGU  - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

OMPR.K=OMPR.J+DT*PULSE((MPR.J-OMPR.J),1,1)/DT                  25, L
OMPR=MPR                                                       25.1, N
    OMPR  - ($/CUSTOMER/YEAR) OLD MULTI-PARTY RATE
    MPR   - ($/CUSTOMER/YEAR) MULTI-PARTY RATE

OSPR.K=OSPR.J+DT*PULSE((SPR.J-OSPR.J),1,1)/DT                  26, L
OSPR=SPR                                                       26.1, N
    OSPR  - ($/CUSTOMER/YEAR) OLD SINGLE-PARTY RATE
    SPR   - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE
```

4.1 MULTI-PARTY RATES

MPR.K=MPR.J+DT*(EMPR.JK-LMPR.JK) 13,L

MPR=IMPR

IMPR=72.42

MPR - ($/CUSTOMER/YEAR) MULTI-PARTY RATE

EMPR - ($/CUSTOMER/YEAR/YEAR) INCREASE IN MULTI-PARTY RATE

LMPR - ($/CUSTOMER/YEAR/YEAR) DECREASE IN MULTI-PARTY RATE

IMPR - ($/CUSTOMER/YEAR) INITIAL MULTI-PARTY RATE

This equation sets the multi-party rate (MPR.K) for each time division according to the previous rate (MPR.J), plus (minus) the increase (decrease) allowed by the Manitoba Public Utilities Board. The initial value (IMPR) represents the average rate of $72.42 for this service, as listed in the General Tariff of the Manitoba Telephone System (MTS 1987b).

4.2 INCREASE IN MULTI-PARTY RATE

EMPR.KL=CLIP(MPR.K*REGU.K,0,REGU.K,0) 14,R

EMPR - ($/CUSTOMER/YEAR/YEAR) INCREASE IN MULTI-PARTY RATE

MPR - ($/CUSTOMER/YEAR) MULTI-PARTY RATE

REGU - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

The increase in multi-party rate (EMPR) is set to the existing rate (MPR) times the fractional increase allowed by the regulator (REGU), if the regulatory adjustment allowance is positive, otherwise there is no increase allowed. This equation allows the model to respond to increases in rates charged for multi-party service.

4.3 DECREASE IN MULTI-PARTY RATE

LMPR.KL=CLIP(0,MPR.K*REGU.K,REGU.K,0) 15,R

LMPR - ($/CUSTOMER/YEAR/YEAR) DECREASE IN MULTI-PARTY RATE

MPR - ($/CUSTOMER/YEAR) MULTI-PARTY RATE

REGU - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

This rate computes the amount by which the multi-party rate may be reduced (LMPR), if the regulatory adjustment allowance is negative, otherwise there is no decrease allowed. This equation allows the model to respond to fractional decreases in rates charged for multi-party service.

4.4 REGULATORY ADJUSTMENT ALLOWANCE

REGU.K=-(TARI.K/STAR)-PRP.K 16,A

STAR=3.7687E8

REGU - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

TARI - ($/YEAR) TOTAL AVERAGE ANNUAL REVENUE EFFECT

STAR - ($) SYSTEM TOTAL REVENUE

PRP - (1/YEAR) POLITICAL RATE PRESSURE

In this section, the fractional increase allowed by the regulator (REGU) is calculated. The negative representation of revenue effects, as a percentage of total system revenue, is used to model the economic pressures for rate adjustments. For example, if the revenue effects (TARI) of a particular program, at a certain time in the simulation, are negative and are ten percent of the total system revenue, (STAR) then this part of the equation will indicate a required rate increase of ten percent.

In opposition to the economic rate increase requirement is the political rate pressure (PRP). Increased political rate pressure decreases the allowance for rate increases by means of the negative sign for this quantity in the equation. The total annual revenue (STAR) for MTS as indicated in the 1986-87 MTS annual report (MTS 1987c) is taken as a reasonable base for the calculation.

4.5 POLITICAL RATE PRESSURE

PRP.K=AFCL.K*SAMPLE(((NOISE()+.5)*RFS),4,0) 17,A

RFS=0

PRP - (1/YEAR) POLITICAL RATE PRESSURE

AFCL - (1/YEAR) AVERAGE FRACTION OF CUSTOMERS LEAVING

RFS - (1) RANDOM FACTOR SWITCH

This equation calculates the political rate pressure (PRP) based upon the average fraction of customers leaving the network (AFCL), multiplied by a random factor that is sampled every four years to represent fluctuations in the ideology of the political party in power, with four years representing the normal length of time between elections. NOISE() is a DYNAMO function that generates random numbers between -.5 and +.5 with a uniform probability distribution. It is set, here, to give a multiplier of between 0 (no political pressure) and 1 (full political pressure - i.e., the full effect of the fraction of customers leaving the system is utilized to prevent further regulatory rate increases). The random factor (RFS) can be experimentally varied to model different assumptions of intensity of political concern.

4.6 AVERAGE FRACTION OF CUSTOMERS LEAVING

AFCL.K=SMOOTH(((RMPL.JK+RSPL.JK)/(NRMP.K+NRSP.K)),1) 18,A

AFCL - (1/YEAR) AVERAGE FRACTION OF CUSTOMERS LEAVING

RMPL - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS LEAVING

RSPL - (CUSTOMERS/YEAR) RATE OF SINGLE-PARTY CUSTOMERS LEAVING

NRMP - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS

NRSP - (CUSTOMERS) NEW SINGLE-PARTY CUSTOMERS

The fraction of customers leaving the network (AFCL) is calculated by adding the multi-party customers leaving (RMPL) to the single-party customers leaving (RSPL) and dividing by the sum of the rural multi- and single-party customer categories (NRMP+NRSP). A delay (SMOOTH) is introduced to allow for the effects to be calculated and recognized by the public.

4.7 SINGLE-PARTY RATES

SPR.K=SPR.J+DT*(ESPR.JK-LSPR.JK) 19,L

SPR=ISPR

ISPR=95.22

SPR - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE

ESPR - ($/CUSTOMER/YEAR/YEAR) INCREASE IN SINGLE-PARTY RATE

LSPR - ($/CUSTOMER/YEAR/YEAR) DECREASE IN SINGLE-PARTY RATE

ISPR - ($/CUSTOMER/YEAR) INITIAL SINGLE-PARTY RATE

This equation sets the single-party rate (SPR.K) for each time division according to the previous rate (SPR.J), plus (minus) the increase (decrease) allowed by the regulator. The initial value (ISPR) of $95.22 represents the average rate for this service, as listed in the General Tariff of the Manitoba Telephone System (MTS 1987b).

4.8 INCREASE IN SINGLE-PARTY RATE

ESPR.KL=CLIP(SPR.K*REGU.K,0,REGU.K,0) 20,R

ESPR - ($/CUSTOMER/YEAR/YEAR) INCREASE IN SINGLE-PARTY RATE

SPR - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE

REGU - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

The increase in the single-party rate (ESPR) is set to the existing rate (SPR) times the increase allowed by the regulator (REGU), if the regulatory adjustment allowance is positive, otherwise there is no increase allowed. This equation allows the model to respond to increases in rates charged for single-party service.

4.9 DECREASE IN SINGLE-PARTY RATE

LSPR.KL=CLIP(0,SPR.K*REGU.K,REGU.K,0) 21,R

LSPR - ($/CUSTOMER/YEAR/YEAR) DECREASE IN SINGLE-PARTY RATE

SPR - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE

REGU - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

This rate computes the amount by which the single-party rate may be reduced (LSPR), if the regulatory adjustment allowance is negative, otherwise there is no decrease allowed. This equation allows the model to respond to decreases in rates charged for single-party service.

4.10 PREMIUM SERVICE RATES

PSR.K=PSR.J+DT*(EPSR.JK-LPSR.JK) 22,R

PSR=37.2

PSR - ($/CUSTOMER/YEAR) PREMIUM SERVICE RATE

EPSR - ($/CUSTOMER/YEAR/YEAR) INCREASE IN PREMIUM SERVICE RATE

LPSR - ($/CUSTOMER/YEAR/YEAR) DECREASE IN PREMIUM SERVICE RATE

This premium service rate (PSR) is basically an annual surcharge for the conversion from multi- to single-party service. This equation sets the premium service rate for each time division (PSR.K) according to the previous rate (PSR.J), plus (minus) the percentage increase (decrease) allowed by the regulator. The initial value ($37.20) represents the average rate for this service, as listed in the General Tariff of the Manitoba Telephone System (MTS 1987b).

4.11 INCREASE IN PREMIUM SERVICE RATE

EPSR.KL=CLIP(PSR.K*REGU.K,0,REGU.K,0) 23,R

EPSR - ($/CUSTOMER/YEAR/YEAR) INCREASE IN PREMIUM SERVICE RATE

PSR - ($/CUSTOMER/YEAR) PREMIUM SERVICE RATE

REGU - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

The increase in premium service rate (EPSR) is set to the existing rate (PSR) times the increase allowed by the regulator (REGU), if the regulatory adjustment allowance is positive, otherwise there is no increase allowed. This equation allows the model to respond to increases in rates charged for premium service.

4.12 DECREASE IN PREMIUM SERVICE RATE

LPSR.KL=CLIP(0,PSR.K*REGU.K,REGU.K,0) 24,R

LPSR - ($/CUSTOMER/YEAR/YEAR) DECREASE IN PREMIUM SERVICE RATE

PSR - ($/CUSTOMER/YEAR) PREMIUM SERVICE RATE

REGU - (1/YEAR) REGULATORY ADJUSTMENT ALLOWANCE

This rate computes the amount by which the premium service rate may be reduced (LPSR), if the regulatory adjustment allowance is negative, otherwise there is no decrease allowed. This equation allows the model to respond to decreases in rates charged for premium service.

4.13 OLD MULTI-PARTY RATE

OMPR.K=OMPR.J+DT*PULSE((MPR.J-OMPR.J),1,1)/DT 25,L

OMPR=MPR

OMPR - ($/CUSTOMER/YEAR) OLD MULTI-PARTY RATE

MPR - ($/CUSTOMER/YEAR) MULTI-PARTY RATE

This equation produces a one year delayed version of the multi-party rate (OMPR) to be used for comparison purposes.

4.14 OLD SINGLE PARTY RATE

OSPR.K=OSPR.J+DT*PULSE((SPR.J-OSPR.J),1,1)/DT 26,L

OSPR=SPR

OSPR - ($/CUSTOMER/YEAR) OLD SINGLE-PARTY RATE

SPR - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE

This equation produces a one year delayed version of the single-party rate (OSPR) to be used for comparison purposes.

CHAPTER 5

FINANCIAL SECTOR

The financial sector of the model (see Figure 4) comprises a set of assumptions about capital investment, revenues, and revenue effects. These relationships are described in the following chapter, based upon the DYNAMO equations (refer to Table 4 for a listing of equations) that represent them.

The fundamental assumption regarding the analysis of the time value of money for this model is the attempt to systematically exclude inflation. In order to apply this method, all dollar amounts are stated in terms of 1988 (the base year). For consistency, the interest rate used in the model is an estimated value of the real cost of money, with inflation removed (American Telephone and Telegraph 1977). The derivation of this estimated value is described in Section 5.9.

TABLE 4

LISTING OF DYNAMO EQUATIONS USED IN THE FINANCIAL SECTOR

```
SPCI.K=SPCI.J+DT*(RIIRSP.JK-RDPRSP.JK)                        27, L
SPCI=INRSP*ECPC                                               27.1, N
ECPC=8621                                                     27.2, C
   SPCI   - ($) SINGLE-PARTY CAPITAL INVESTMENT
   RIIRSP - ($/YEAR) RATE OF INCREASE IN EQUIPMENT INVESTMENT
   RDPRSP - ($/YEAR) RATE OF DEPRECIATING RURAL SINGLE-PARTY INVESTMENT
   INRSP  - (CUSTOMERS) INITIAL RURAL SINGLE-PARTY CUSTOMERS
   ECPC   - ($/CUSTOMERS) EQUIPMENT COST PER CUSTOMER
```

TABLE (continued) 4

LISTING OF DYNAMO EQUATIONS USED IN THE FINANCIAL SECTOR

```
RIIRSP.KL=CLIP(ECPC,ECPC*EOS,TSUP,TIME.K)*RMPC.JK                      28, R
EOS=.58                                                                 28.1, C
    RIIRSP - ($/YEAR) RATE OF INCREASE IN EQUIPMENT INVESTMENT
    ECPC   - ($/CUSTOMERS) EQUIPMENT COST PER CUSTOMER
    EOS    - (1) ECONOMIES OF SCALE
    TSUP   - (YEAR) TIME OF START OF UNIVERSAL PROGRAM
    RMPC   - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING

RDPRSP.KL=SPCI.K/EUL                                                    29, R
EUL=18                                                                  29.1, C
    RDPRSP - ($/YEAR) RATE OF DEPRECIATING RURAL SINGLE-PARTY INVESTMENT
    SPCI   - ($) SINGLE-PARTY CAPITAL INVESTMENT
    EUL    - (YEAR) EQUIPMENT USEFUL LIFE

MPRI.K=NRMP.K*(MPR.K-MPE)                                               30, A
MPE=468.36                                                              30.1, C
    MPRI   - ($/YEAR) MULTI-PARTY NET REVENUE
    NRMP   - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS
    MPR    - ($/CUSTOMER/YEAR) MULTI-PARTY RATE
    MPE    - ($/CUSTOMER/YEAR) MULTI-PARTY EXPENSES

PSRI.K=NRSP.K*PSR.K                                                     31, A
    PSRI   - ($/YEAR) PREMIUM SERVICE NET REVENUE
    NRSP   - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS
    PSR    - ($/CUSTOMER/YEAR) PREMIUM SERVICE RATE

SPRI.K=NRSP.K*(SPR.K-SPE)                                               32, A
SPE=410.45                                                              32.1, C
    SPRI   - ($/YEAR) SINGLE-PARTY NET REVENUE
    NRSP   - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS
    SPR    - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE
    SPE    - ($/CUSTOMER/YEAR) SINGLE-PARTY EXPENSES

RSPRI.K=SPRI.K+PSRI.K+MPRI.K-COCRSP.K-RDPRSP.JK+MPTS                    33, A
    RSPRI  - ($/YEAR) RURAL SINGLE-PARTY NET REVENUE EFFECT
    SPRI   - ($/YEAR) SINGLE-PARTY NET REVENUE
    PSRI   - ($/YEAR) PREMIUM SERVICE NET REVENUE
    MPRI   - ($/YEAR) MULTI-PARTY NET REVENUE
    COCRSP - ($/YEAR) COST OF CAPITAL FOR RURAL SINGLE-PARTY
    RDPRSP - ($/YEAR) RATE OF DEPRECIATING RURAL SINGLE-PARTY INVESTMENT
    MPTS   - ($/YEAR) MULTI-PARTY TOLL SUBSIDY

TARI.K=SMOOTH(RSPRI.K,1)                                                34, A
    TARI   - ($/YEAR) TOTAL AVERAGE ANNUAL REVENUE EFFECT
    RSPRI  - ($/YEAR) RURAL SINGLE-PARTY NET REVENUE EFFECT

COCRSP.K=SPCI.K*INTR                                                    35, A
INTR=.087                                                               35.1, C
MPTS=PNRMP*(MPE-IMPR)+INRSP*(SPE-ISPR)                                  35.2, N
    COCRSP - ($/YEAR) COST OF CAPITAL FOR RURAL SINGLE-PARTY
    SPCI   - ($) SINGLE-PARTY CAPITAL INVESTMENT
    INTR   - (1/YEAR) INTEREST RATE
    MPTS   - ($/YEAR) MULTI-PARTY TOLL SUBSIDY
    PNRMP  - (CUSTOMERS) PRESENT NUMBER OF MULTI-PARTY CUSTOMERS
    MPE    - ($/CUSTOMER/YEAR) MULTI-PARTY EXPENSES
    IMPR   - ($/CUSTOMER/YEAR) INITIAL MULTI-PARTY RATE
    INRSP  - (CUSTOMERS) INITIAL RURAL SINGLE-PARTY CUSTOMERS
    SPE    - ($/CUSTOMER/YEAR) SINGLE-PARTY EXPENSES
    ISPR   - ($/CUSTOMER/YEAR) INITIAL SINGLE-PARTY RATE
```

5.1 SINGLE PARTY CAPITAL INVESTMENT

SPCI.K=SPCI.J+DT*(RIIRSP.JK-RDPRSP.JK) 27,L

SPCI=INRSP*ECPC

ECPC=8621

SPCI - ($) SINGLE-PARTY CAPITAL INVESTMENT

RIIRSP - ($/YEAR) RATE OF INCREASE IN EQUIPMENT INVESTMENT

RDPRSP - ($/YEAR) RATE OF DEPRECIATING RURAL SINGLE-PARTY INVESTMENT

INRSP - (CUSTOMERS) INITIAL RURAL SINGLE-PARTY CUSTOMERS

ECPC - ($/CUSTOMERS) EQUIPMENT COST PER CUSTOMER

The single-party capital investment (SPCI) computed in this section represents strictly the incremental cost of the customers converting from multi-party to single-party service, and does not address the total capital costs of the existing network. Since the capital structure of MTS comprises over 91% debt (MTS 1987c), it seems reasonable to assume that the incremental capital costs of a single-party program would be financed by further borrowing. The costs of such additional borrowing would then be recovered by increasing the charges to MTS customers (CP Wire 1988). This assumption allows the use of the MTS effective average debt rate of 12.5% (MTS 1987c) in determining the estimated real cost of capital for use in this model (see Section 5.9).

Single-party capital investment (SPCI) is increased by additional conversions (RIIRSP - discussed in the next section), and decreased by the depreciation of the equipment (RDPRSP - see Section 5.3). The initial level is set by the initial number of converted single-party customers (INRSP), multiplied by the average incremental equipment cost per customer (ECPC). The value used for ECPC ($8621) is based upon MTS information (MTS 1988), and is not expected by MTS to change substantially in the near-term for normal purchase quantities.

The value for ECPC at MTS that has been determined in this manner appears to be substantially higher than equivalent equipment costs in the United States (International Data Corporation 1987) or other Canadian prairie provinces (North Battleford News - Optimist 1988). Other technologies for single-party access, such as the digital radio system recently offered by Microtel Limited (1988) have the potential to substantially lower the ECPC value for future installations. ECPC, therefore, can be easily altered in the model, so that experimental simulation runs with different ECPC values can be used to determine sensitivity to changes in equipment costs.

5.2 RATE OF INCREASE IN EQUIPMENT INVESTMENT

RIIRSP.KL=CLIP(ECPC,ECPC*EOS,TSUP,TIME.K)*RMPC.JK 28,R

EOS=.58

RIIRSP - ($/YEAR) RATE OF INCREASE IN EQUIPMENT INVESTMENT

ECPC - ($/CUSTOMERS) EQUIPMENT COST PER CUSTOMER

EOS - (1) ECONOMIES OF SCALE

TSUP - (YEAR) TIME OF START OF UNIVERSAL PROGRAM

RMPC - (CUSTOMERS/YEAR) RATE OF MULTI-PARTY CUSTOMERS CONVERTING

This rate equation sets the increase in investment (RIIRSP) equal to the single-party capital costs of that time period. The capital costs are determined in one of two ways, depending upon the program that is operating at the time. If the premium service program is offering conversion on a voluntary basis, at the option of each individual customer, then the stated equipment costs per customer (ECPC) will apply. If the universal single-party conversion program is operating, however, savings can be realized through the resulting economies of scale. The discount fraction for economies of scale (EOS) is based upon MTS engineering estimates (MTS 1987d), and is not expected to change substantially in the near-term.

5.3 RATE OF DEPRECIATING RURAL SINGLE-PARTY INVESTMENT

RDPRSP.KL=SPCI.K/EUL 29,R

EUL=18

RDPRSP - ($/YEAR) RATE OF DEPRECIATING RURAL SINGLE-PARTY INVESTMENT

SPCI - ($) SINGLE-PARTY CAPITAL INVESTMENT

EUL - (YEAR) EQUIPMENT USEFUL LIFE

This rate (RDPRSP) decreases the level of the capital investment according to the depreciation of the equipment. The depreciation is calculated in a straight-line method (American Telephone and Telegraph 1977), using an average useful life of the equipment of 18 years. The useful life (EUL) of the relevant equipment is consistent with industry averages (American Telephone and Telegraph 1977). This number represents an aggregate, since several categories of equipment would be used.

5.4 MULTI-PARTY NET REVENUE

MPRI.K=NRMP.K*(MPR.K-MPE) 30,A

MPE=468.36

MPRI - ($/YEAR) MULTI-PARTY NET REVENUE

NRMP - (CUSTOMERS) NUMBER OF MULTI-PARTY CUSTOMERS

MPR - ($/CUSTOMER/YEAR) MULTI-PARTY RATE

MPE - ($/CUSTOMER/YEAR) MULTI-PARTY EXPENSES

The net revenue from the rural multi-party customers (MPRI) is calculated by multiplying the number of customers (NRMP) by the difference between the per customer annual rates (MPR), and the per customer annual expenses (MPE). The multi-party expense (MPE) value is based upon MTS internal service costing studies (MTS 1987e), and reflects the best estimate that is available. It should be noted that difficulties in the assignment of costs to particular services and service categories are common throughout the telecommunications industry (Brock 1981, United States General Accounting Office 1986), and, consequently, assigned costs are based on estimations.

5.5 PREMIUM SERVICE NET REVENUE

PSRI.K=NRSP.K*PSR.K 31,A

PSRI - ($/YEAR) PREMIUM SERVICE NET REVENUE

NRSP - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS

PSR - ($/CUSTOMER/YEAR) PREMIUM SERVICE RATE

The net revenue from the premium service customers (PSRI) is calculated by multiplying the number of customers (NRSP) by the premium service rate (PSR). Since the premium service rate (PSR) is essentially a surcharge, no additional expenses are incurred for billing or administration. The additional expenses for the service are reflected in the single-party expenses (SPE), which are included in the calculation of single-party net revenue (SPRI). This calculation is discussed in the next section.

5.6 SINGLE-PARTY NET REVENUE

SPRI.K=NRSP.K*(SPR.K-SPE) 32,A

SPE=410.45

SPRI - ($/YEAR) SINGLE-PARTY NET REVENUE

NRSP - (CUSTOMERS) POOL OF SINGLE-PARTY CUSTOMERS

SPR - ($/CUSTOMER/YEAR) SINGLE-PARTY RATE

SPE - ($/CUSTOMER/YEAR) SINGLE-PARTY EXPENSES

The net revenue from the new single-party customers (SPRI) is calculated in a manner similar to that used for multi-party revenue in Section 5.4. Thus, the number of customers (NRSP) is multiplied by the difference between the per customer annual rates (SPR), and the per customer annual expenses (SPE). The single-party expense (SPE) value is based upon MTS internal service costing studies (MTS 1987e).

5.7 RURAL SINGLE-PARTY NET REVENUE EFFECT

RSPRI.K=SPRI.K+PSRI.K+MPRI.K-COCRSP.K-RDPRSP.JK+MPTS 33,A

RSPRI - ($/YEAR) RURAL SINGLE-PARTY NET REVENUE EFFECT

SPRI - ($/YEAR) SINGLE-PARTY NET REVENUE

PSRI - ($/YEAR) PREMIUM SERVICE NET REVENUE

MPRI - ($/YEAR) MULTI-PARTY NET REVENUE

COCRSP - ($/YEAR) COST OF CAPITAL FOR RURAL SINGLE-PARTY

RDPRSP - ($/YEAR) RATE OF DEPRECIATING RURAL SINGLE-PARTY INVESTMENT

MPTS - ($/YEAR) MULTI-PARTY TOLL SUBSIDY

The total incremental financial impact of single-party conversion on MTS (RSPRI) is determined by the summation of all the constituent net revenues, less related costs. These include the multi-party (MPRI), single-party (SPRI), and premium service (PSRI) net revenues, as well as the cost of capital (COCRSP), depreciation (RDPRSP), and toll subsidy (MPTS). The multi-party toll subsidy (MPTS) is discussed in detail in Section 5.9, in conjunction with the cost of capital (COCRSP). The rate of depreciating the rural single-party investment (RDPRSP), incorporates the depreciation assumptions which are discussed in Section 5.3.

5.8 TOTAL AVERAGE ANNUAL REVENUE EFFECT

TARI.K=SMOOTH(RSPRI.K,1) 34,A

TARI - ($/YEAR) TOTAL AVERAGE ANNUAL REVENUE EFFECT

RSPRI - ($/YEAR) RURAL SINGLE-PARTY NET REVENUE EFFECT

The political or public perception of the financial impacts of a single-party program at MTS is expected to be based upon a delayed response to the actual cash flows. The United States General Accounting Office (1986) has recognized the existence of such delays for customers to assess and react to price changes for telecommunications services. A single-party program at MTS, with a less direct financial impact on customers, is likely to similarly elicit a delayed public awareness of financial implications. Therefore, this variable (TARI) is simply a delayed version of the previous variable (RSPRI). TARI is used to show the financial impact after the delay in time for reporting and public assessment.

5.9 COST OF CAPITAL

COCRSP.K=SPCI.K*INTR 35,A

INTR=.087

MPTS=PNRMP*(MPE-IMPR)+INRSP*(SPE-ISPR)

COCRSP - ($/YEAR) COST OF CAPITAL FOR RURAL SINGLE-PARTY

SPCI - ($) SINGLE-PARTY CAPITAL INVESTMENT

INTR - (1/YEAR) INTEREST RATE

MPTS - ($/YEAR) MULTI-PARTY TOLL SUBSIDY

PNRMP - (CUSTOMERS) PRESENT NUMBER OF MULTI-PARTY CUSTOMERS

MPE - ($/CUSTOMER/YEAR) MULTI-PARTY EXPENSES

IMPR - ($/CUSTOMER/YEAR) INITIAL MULTI-PARTY RATE

INRSP - (CUSTOMERS) INITIAL RURAL SINGLE-PARTY CUSTOMERS

SPE - ($/CUSTOMER/YEAR) SINGLE-PARTY EXPENSES

ISPR - ($/CUSTOMER/YEAR) INITIAL SINGLE-PARTY RATE

As a result of using the rationale for financial analyses that is described in the introduction to this chapter, all dollar amounts in the model are stated in 1988 (base year) dollars. The value (INTR) that has been developed to estimate the real cost of capital for MTS follows from the discussions in the introduction to this chapter and in Section 5.1. The effective average debt rate for MTS of 12.5% (MTS 1987c) is used as the nominal interest rate, and an inflation rate of 3.8%, which has been estimated from historical data and projected trends (Statistics Canada 1987, Statistics Canada 1988), is subtracted to remove the effects of inflation from INTR, the estimated cost of capital used in the model.

Although alternative methods exist for including the time value of money in financial analyses (American Telephone and Telegraph 1977), modeling these alternative methods would introduce additional complications into the model, without substantially increasing the usefulness of the model. The simulation results would be more difficult to communicate with dollars valued at different amounts in different years. Since the bases for the simulation input variables are planning assumptions and estimations of future revenues and costs, simulation results should be interpreted accordingly. The use of 1988 dollars is felt to facilitate the communication of simulation results.

The annual cost of capital in dollars (COCRSP) is calculated by multiplying the capital investment (SPCI) by the annual interest rate (INTR - representing the estimated real cost of capital). INTR can be easily altered in the model, so that experimental simulation runs with different values of INTR can be used to determine sensitivity to changes in the real cost of capital.

It is a well-documented fact that long-distance (toll) service provides a subsidy for local (basic) service (MTS 1987c, Brock 1981, Coll 1986, Park and Mitchell 1987, Communications Canada 1987, and Bell Canada 1988). This fact, in conjunction with the telecommunications industry trend toward cost-based pricing of services (American Telephone and Telegraph 1977, Littlechild 1979, MacDonald 1984, Coll 1986, United States General Accounting Office 1986, Federal/Provincial Examination of Telecommunications Pricing and the Universal Availability of Affordable Telephone Service 1986, Bell Canada 1988), leads to the assumption, used in the model, that long-distance revenues provide a subsidy for existing local services (both single- and multi-party) at MTS. Further to this assumption are the political sensitivities that will prevent elimination or substantial reduction of this subsidy, as well as the expectation that future cost-based service pricing will prevent any increase in the subsidy. The estimated 1988 subsidy value is therefore calculated, and assumed to remain constant at that level throughout the simulation. Thus, the initially computed constant equation for the multi-party toll subsidy (MPTS) estimates the present subsidy provided for these customers from toll revenues by multiplying the present number of customers in each category (PNRMP, INRSP) by the difference between the respective annual rates (IMPR, ISPR) and expenses (MPE, SPE) at the present time.

CHAPTER 6

BASE RUN

Effective strategic planning requires an understanding of future possibilities, based upon the best available current information. Tools for strategic planning, such as this simulation model, can attempt to present detailed views of the system being studied. Initially, this model is run with values set to represent the most likely future environmental conditions (referred to as the "base run"). Then, as discussed in Chapter 7, experimental simulations are run to investigate the effects of changes in variables on the system.

6.1 CRITICAL VARIABLES

The values for the model variables used in the base run simulation reflect recent trends and policies. Assumptions regarding these values have been discussed in previous sections. The controllable variables reflect the present policies of MTS, including the policies announced in the "Service for the Future" plan (MTS 1988). The uncontrollable variables represent the most likely future environmental conditions based upon recent trends. The results of this base run are then used as a basis for comparing the changes in the model conditions resulting from changes to variables in experimental simulation runs.

The following list of critical variables provides, for each variable: a description; characterization as controllable or uncontrollable; initial (base run) value; and, a discussion of the relationship to present organizational policies.

- VARIABLE NAME: MPG
- DESCRIPTION: Fractional Growth of Manitoba Population
- CATEGORY: Uncontrollable
- INITIAL VALUE (units): .0067 (1/year)
- RELATIONSHIP: Since the market penetration for basic telephone service is so high in Manitoba (approximately 98%), the main factor which generates growth in the number of telephone customers is growth in the general population.

- VARIABLE NAME: INFR
- DESCRIPTION: Increase Threshold for Reaction
- CATEGORY: Uncontrollable
- INITIAL VALUE (units): .03 (1)
- RELATIONSHIP: A substantial part of public and regulatory opposition to price increases relates to the publicly-perceived magnitude of the increase. This variable represents the threshold percentage for price increases, below which only minimal opposition would be expected.

- VARIABLE NAME: RMPLTA
- DESCRIPTION: Rate of Multi-Party Customers Leaving Table
- CATEGORY: Uncontrollable
- INITIAL VALUE: 0/0/.005/.01/.015/.02/.025/.032/.042/.058/.078/.1
- RELATIONSHIP: This variable represents the price elasticity of demand for basic multi-party telephone service. Pricing decisions will affect the number of customers who leave the network by the relationships determined from values of this variable. While the prices are somewhat controllable by decision makers, the demand elasticity is not. The values used in this table represent the North American cultural interpretation of the value of telephone service (see Section 3.3), and are not able to be controlled by telephone company decision makers. Simulation runs with alternative estimates for this demand function allow the evaluation of system sensitivity to demand elasticity, which will have a large impact on pricing decisions.

- VARIABLE NAME: RSPLTA
- DESCRIPTION: Rate of Single-Party Customers Leaving Table
- CATEGORY: Uncontrollable
- INITIAL VALUE: 0/0/.005/.01/.015/.02/.025/.032/.042/.058/.078/.1
- RELATIONSHIP: This variable represents the price elasticity of demand for basic single-party telephone service. It is analogous to RMPLTA, which is described above.

- VARIABLE NAME: INTR
- DESCRIPTION: Interest Rate
- CATEGORY: Uncontrollable
- INITIAL VALUE (units): .087 (1/year)
- RELATIONSHIP: The relevant interest rate (nominal cost of capital, less inflation) has a major impact on decisions relating to capital investments, such as the program alternatives presently included in this model.

- VARIABLE NAME: RFS
- DESCRIPTION: Random Factor Switch
- CATEGORY: Uncontrollable
- INITIAL VALUE (units): 0 (1/year)
- RELATIONSHIP: Political pressure for rate increase containment will depend upon the political party in power, and other randomly occurring political stimuli. MTS, as a provincial crown corporation, has to recognize political sensitivities as a major element in strategic planning decisions. This variable allows the model to respond to a random input which simulates political events.

- VARIABLE NAME: ECPC
- DESCRIPTION: Equipment Cost Per Customer
- CATEGORY: Semi-controllable
- INITIAL VALUE (units): 8621 ($/customer)
- RELATIONSHIP: The per-customer cost of providing single-party service is a critical factor in program decisions. This variable provides the model with the capability of simulating the results of, for example, a major technological innovation that would substantially lower equipment costs.

- VARIABLE NAME: PSCC
- DESCRIPTION: Premium Service Customer Charge
- CATEGORY: Controllable
- INITIAL VALUE (units): 515 ($)
- RELATIONSHIP: The number of customers making a voluntary conversion from multi-party to single-party service will depend on the price of converting. This variable allows evaluation of conversion pricing options.

- VARIABLE NAME: TSUP
- DESCRIPTION: Time of Start of Universal Program
- CATEGORY: Controllable
- INITIAL VALUE (units): 2 (years)
- RELATIONSHIP: One of the major considerations in planning for a Universal Conversion Program is the timing for beginning the program. This variable allows simulations to be run for alternative program initiation timings.

- VARIABLE NAME: USPY
- DESCRIPTION: Years to Complete Universal Program
- CATEGORY: Controllable
- INITIAL VALUE (units): 7 (years)
- RELATIONSHIP: The duration of a Universal Conversion Program is another major decision variable for strategic planning. This variable allows simulations to be run for alternative program durations.

6.2 RESULTS

The criteria by which the relative success of a single-party conversion program are measured will be complex and dynamic in reality. For the purposes of this study, the major factors of: (1) reducing the number of rural multi-party customers, (2) minimizing the capital investment required, and (3) minimizing the rates that must be charged to customers, have been taken as the dominate measures of success.

In the base run simulation, representing the scenario of no major policy changes from the present direction, the number of multi-party customers is reduced from the present 46,600 to zero in year 10, as shown in Figure 8.

Figure 8 Base Run
NUMBER OF MULTI-PARTY CUSTOMERS (1000s)

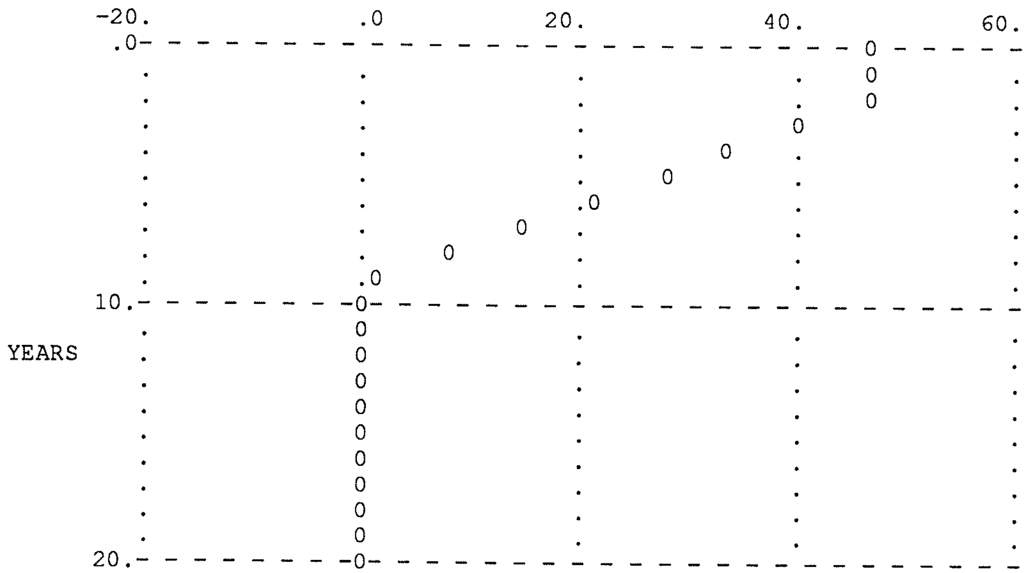
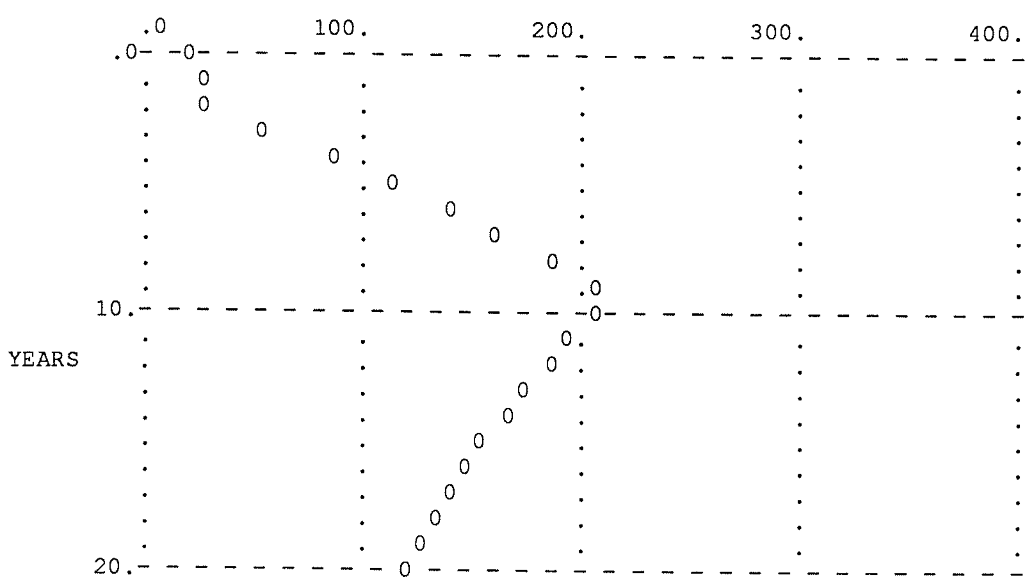
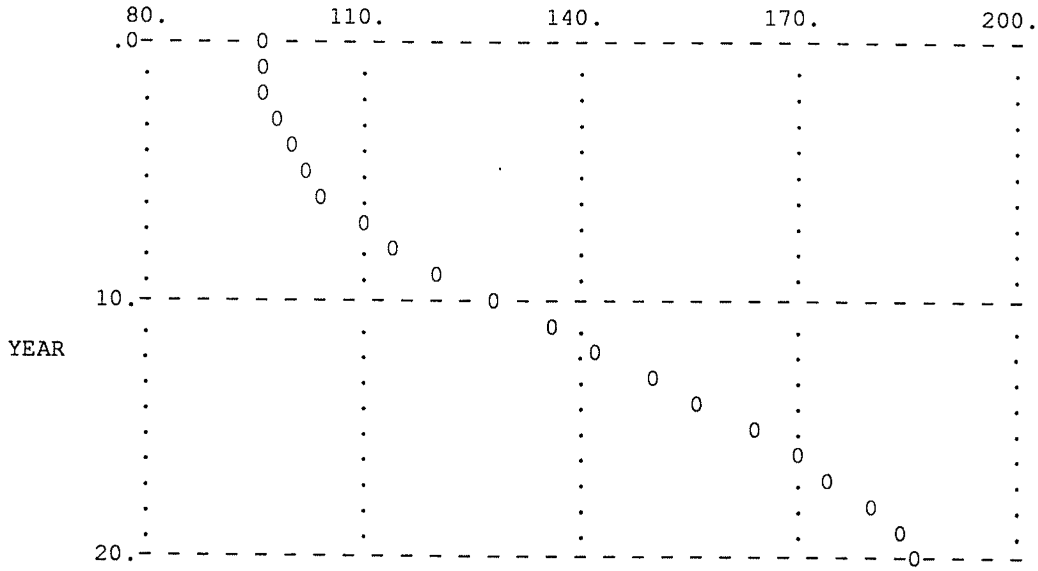


Figure 9 Base Run
CAPITAL INVESTMENT ($ million)



The required capital investment peaked at $207.8 million in year 9, as illustrated in Figure 9, while the relevant rate (Single Party Rate) increased 34 percent in the first 10 years, and a further 47 percent in the second 10 years, as shown in Figure 10.

Figure 10 Base Run
ANNUAL RATES ($/YEAR)



CHAPTER 7

EXPERIMENTS

One of the best ways to understand the effects of the experimental changes on the system is to compare the system conditions over the simulation time in the experimental simulations with the "most likely" system conditions of the base run. In general, the variables being changed for the experimental simulations may be divided into two classes: (1) uncontrollable variables, or environmental factors - those things that cannot be changed by the decision makers conducting the study, and (2) controllable variables, which are the "control levers" that the decision makers can manipulate to accomplish organizational goals.

Experiments have been devised, using this simulation model, to investigate the effects of various changes to both controllable and uncontrollable variables. These experiments, then, model the behaviour of the system under conditions of environmental "shock", or changes in organizational policies.

The following experiments were run on the University of Manitoba mainframe computer under Dynamo. The experimental results for each experiment are discussed in relation to the Base Run results. In each section, the experimental variables are shown for the specific experiment being discussed, with the original value and experimental values indicated.

7.1 CHANGING POPULATION GROWTH

Although Manitoba population growth is not expected to change substantially from the forecast rate of .0067 fractional growth per year, as discussed in Section 3.2, an experiment is undertaken to investigate the system sensitivity to changes in the population growth. For the purposes of this experiment, values equal to one-half and double the expected population growth rate are felt to provide an adequate, or realistic, range of variability. The intention in this experiment is not to plan for catastrophic population changes, but rather to provide a wide enough experimental range above and below the expected value to detect potential system sensitivities to realistic changes in the rate of population growth. In addition, extreme population growth values, beyond the realistic range, have been included in this experiment, both to more fully explore the capabilities of the model, and to better understand the system effects of major changes in this variable.

With all other variables held at the same values used for the base run simulation, the population growth percentage is changed for the simulation runs in this experiment.

- EXPERIMENTAL VARIABLE NAME: MPG
- DESCRIPTION: Fractional Growth of Manitoba Population
- CATEGORY: Uncontrollable
- INITIAL VALUE (units): .0067 (1/year)
- EXPERIMENTAL VALUES: 0, .00335, .0134, .1, 1.0

Within the range of one-half to double the initial value for population growth, very little difference in results was noted. The number of multi-party customers was reduced to zero in year 10 for both of the boundary cases for this range. The capital investment peaked at $206.53 million in year 9 for the lower rate, and at $215.07 million in year 10 for the double growth rate. This difference was less than five percent, and the timing of the peak investment was also close (within one year). The rates showed a slightly larger percentage differential at the end of 20 years - about six percent ($194.42 per year for the higher growth rate, versus $183.50 for the lower growth) - compared to the base run of $186.81.

In the more extreme experimental simulations, with population growth between zero and 100 percent, results were less predictable. With zero population growth, for instance, the results were not greatly different from the base run - the number of multi-party customers was reduced to zero in year 9, the capital investment peaked at $207.8 million in year 9, and the rates rose to $186.81 per year. With 100 percent population growth, however, the model went into an arithmetic overflow situation before year 7. Under this extreme growth simulation, the number of multi-party customers was increasing with a geometrically expanding curve, until the model crash just before year 7. By year 6, the capital investment exceeded $823 million and the required annual rate was $2281. With 10 percent population growth, the number of multi-party customers was reduced to zero in year 15, the capital investment peaked in year 14 at $361 million and the annual rates rose to $381 by year 20.

7.2 CHANGING INCREASE THRESHOLD FOR REACTION

The increase threshold for reaction (INFR) may change due to economic sensitivities in the popular press, or other general economic conditions (inflation, recession). In this experiment, the variable is initially set to represent total sensitivity to price increases (i.e., zero threshold). The realistic range of experimental values used is 0 to 0.6. This range is expected to encompass the changes in threshold which may be expected as a result of economic fluctuations, or other normal occurrences. In a further set of experimental simulations beyond the realistic range, extremely high values for this variable (0.1 and 1.0) are explored. This wider range of experimental values for the variable allows an investigation of potential system sensitivities to changes in the threshold value.

With all other variables held at the same values used for the base run simulation, the increase threshold for reaction is changed for the simulation runs in this experiment (see Section 3.6 for further information concerning INFR).

- EXPERIMENTAL VARIABLE NAME: INFR
- DESCRIPTION: Increase Threshold for Reaction
- CATEGORY: Uncontrollable
- INITIAL VALUE (units): .03 (1)
- EXPERIMENTAL VALUES: 0, .06, .1, 1.0

Within the range of one-half to double the initial value for INFR, only very small differences in results were noted. The number of multi-party customers was reduced to zero by year 10 for both the boundary cases for this range, at the same time as in the base run. The peak capital investment occurred in year 9 within this range, with a total amount only .04% less ($207.72 million versus $207.80 million) for the one-half INFR simulation run, compared to either the base run or the double INFR run. In the case of rates, the differences in results were slightly larger. These differences were still quite small in absolute terms, however, with one-half INFR resulting in single-party rates of $186.15 in year 20; double INFR resulting in $186.89, compared to the base run amount of $186.81. The rate difference of $.74 between the boundaries of this range represents a .4% difference. The rate differential in year 10 was only $.10, or .08%, indicating that the percentage difference in rates for this range increased over the duration of the simulation.

In the wider range of 0 to 1.0 INFR, simulation runs demonstrated that the differences in results were no greater than for the range of one-half to double INFR values. In fact, the single-party rates in year 20 for 0 INFR were $186.15, exactly the same as for one-half INFR. Similarly, the upper value for single-party rates in year 20 for 1.0 INFR was exactly the same value ($186.89) as the value for double INFR. The results for reducing the number of multi-party customers to zero, and the required capital investments showed similar limits on the range of variability, with the limits for one-half to double INFR not being exceeded in simulations using 0 to 1.0 INFR.

7.3 CHANGES IN DEMAND ELASTICITY

The representation of demand elasticity initially used in the model is not expected to change drastically in the foreseeable future. This demand elasticity is fairly consistent throughout North America, and has shown only limited change over time. This experiment, then, is run under conditions of dramatic changes in demand elasticity in order to exercise the regulatory feedback process in the model, as well as to investigate the system stability under conditions of environmental shock (see Figure 11 for graphical representation of experimental table values).

With all other variables held at the same values used for the base run simulation, the tables representing the demand elasticity for telephone service are changed for the simulation runs in this experiment.

- EXPERIMENTAL VARIABLE NAME: RMPLTA
- DESCRIPTION: Rate of Multi-Party Customers Leaving Table
- CATEGORY: Uncontrollable
- INITIAL VALUE: (see Figure 5)

    0/0/.005/.01/.015/.02/.025/.032/.042/.058/.078/.1

- EXPERIMENTAL VALUES: (see Figure 11)

    0/0/.01/.02/.03/.04/.05/.064/.084/.116/.156/.2

    0/0/.05/.1/.15/.2/.25/.32/.42/.58/.78/1.0

- EXPERIMENTAL VARIABLE NAME: RSPLTA
- DESCRIPTION: Rate of Single-Party Customers Leaving Table
- CATEGORY: Uncontrollable
- INITIAL VALUE: (see Figure 7)

  0/0/.005/.01/.015/.02/.025/.032/.042/.058/.078/.1
- EXPERIMENTAL VALUES: (see Figure 11)

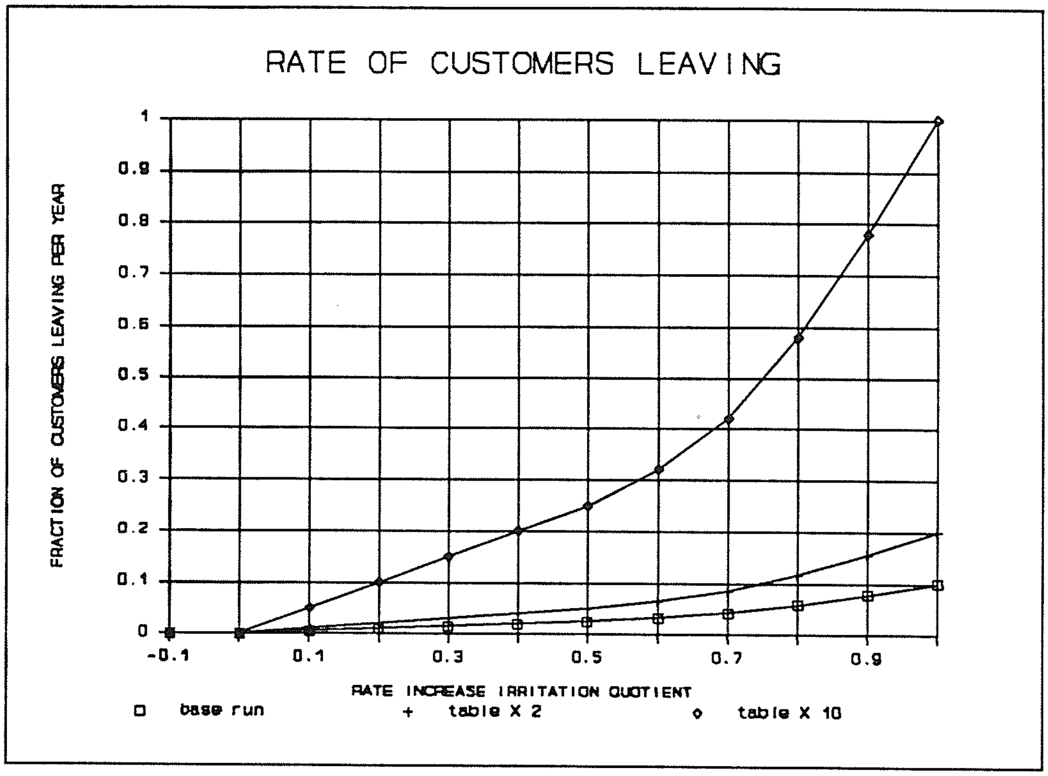
  0/0/.01/.02/.03/.04/.05/.064/.084/.116/.156/.2

  0/0/.05/.1/.15/.2/.25/.32/.42/.58/.78/1.0

The two tables with altered values in simulation runs for this experiment represent the demand elasticity for telephone service (RMPLTA and RSPLTA - see Figure 11). It should be noted that the graphical representation of Figure 11 is applicable to experimental values for either RMPLTA or RSPLTA, since the numerical values are the same. The first experimental runs used values of double the base run amounts for these tables. Even doubling these values represents a substantial departure from expected reality, since the demand elasticity for telephone service has been widely studied (see Sections 3.3 and 3.9 for more information). The results of the simulation runs with double table values showed small, but noticeable differences from the base run in the areas of capital investment and rates. The capital investment still showed a peak in the ninth year, but the amount of the peak was $207.64 million, compared to $207.8 million for the base run. The rates for year 20 showed somewhat more variation, at $183.93, versus $186.81 for the base run.

Figure 11

DEMAND ELASTICITY FOR TELEPHONE SERVICE



As a further test of the sensitivity of critical system results to changes in demand elasticity, the table values were increased one order of magnitude, and system simulations were run. It should be noted that these are very extreme values for these tables. To place the experimental values into perspective: the table values at ten times the initial values would mean that approximately 25% of customers would choose to discontinue their telephone service if the rates increased by 50% more than the threshold level. This is a situation that is quite far removed from the available information on demand elasticity for telephone service (see Sections 3.3 and 3.9). Even with the extreme values (of ten times the base run amounts) used in these simulations, the results were not dramatically different from the base run. The number of multi-party customers was reduced to zero in year ten, and the peak investment still occurred in year nine. The amount of the peak investment was slightly less ($207.02 million versus $207.80 million for the base run). The rates in year 20 showed a more significant difference, with experimental results of $172.54 (versus $186.81 for the base run). The main reason that the results were quite insensitive to major changes in this variable appears to be that the yearly increases in customer rates were not large enough to cause a major exodus of telephone customers, even with the extreme changes in the demand curve.

7.4 CHANGING INTEREST RATE

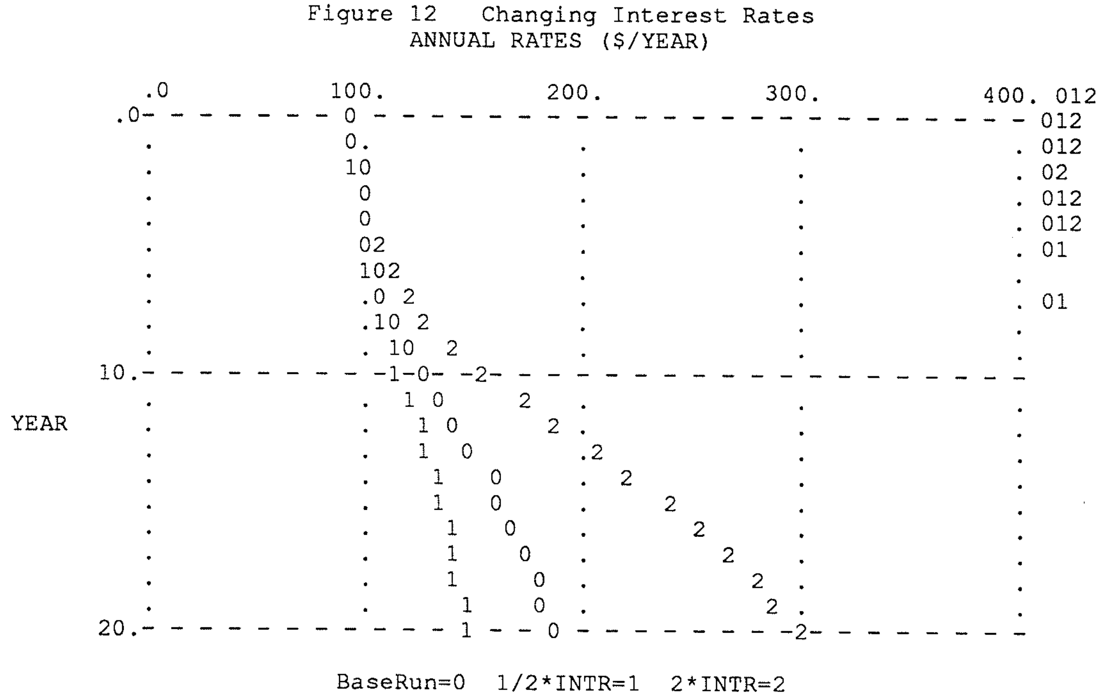
The interest rate is one of the more volatile of the environmental inputs. Real interest rates (i.e., with inflation removed, such as those used in this model), however, tend to be much less volatile than the nominal rates. In spite of the historically limited range of real interest rates, the behaviour of the system in response to changing interest rates is seen as an important area of investigation. Since the real interest rate has such a direct effect on the program costs for capital intensive programs, sensitivities to this variable in the system could have important ramifications for planning decisions. For these reasons, this experimental simulation is initially performed using one-half and double the initial real interest rate to investigate system sensitivities to this input variable. Investigation within this range was considered adequate to cover the realm of realistic possibilities. To further explore system behaviour beyond such realistic interest rate scenarios, experimental simulations are run for real interest rates of zero, as well as 100 percent.

With all other variables held at the same values used for the base run simulation, the interest rate is changed for the simulation runs in this experiment.

- VARIABLE NAME: INTR
- DESCRIPTION: Interest Rate
- CATEGORY: Uncontrollable
- INITIAL VALUE (units): .087 (1/year)
- EXPERIMENTAL VALUES: 0, .0435, .174, 1.0

Within the range of one-half to double the initial value for the interest (INTR), the only differences in results were noted in the area of rates. The number of multi-party customers was reduced to zero by year 10 for both the boundary cases for this range, at the same time as in the base run. The peak capital investment occurred in year 9 within this range, with a total amount of $207.80 million for all runs, the same value as the base run result. In the case of rates, however, the differences in results were substantial. For simulation runs using one-half the initial value for INTR, the rates in year 20 were $145.99, 22% less than the base run result. In the case of double the initial value for INTR, the simulation result for the rates in year 20 was $297.23, a 59% increase over the base run result.

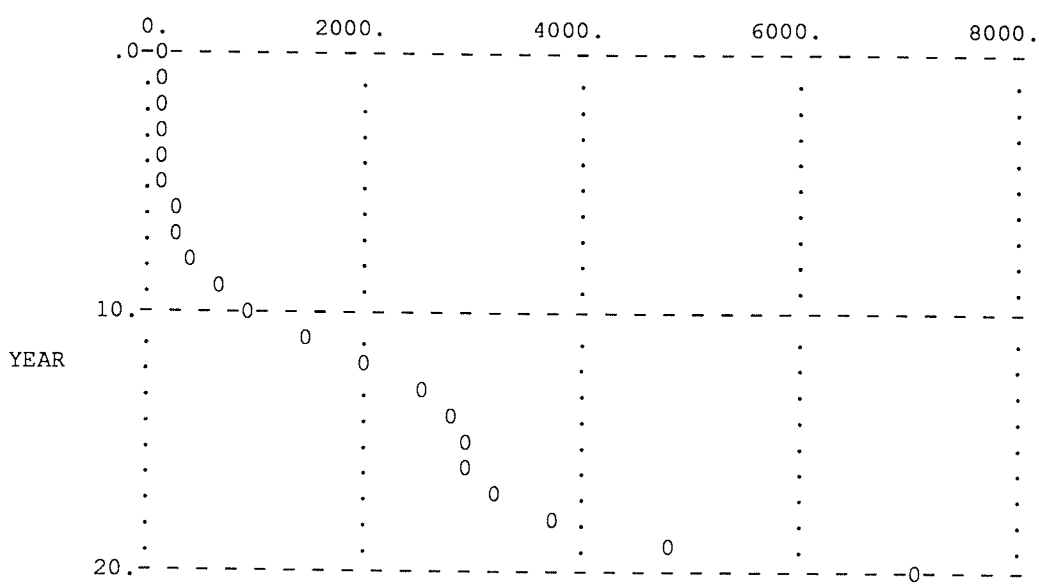
Figure 12 Changing Interest Rates



Results for rates in years 10 and 15 (see Figure 12) showed similar divergences from the base run: for one-half INTR, the 10 year rate was 10% lower, and the 15 year rate was 17% lower; for double INTR, the 10 year rate was 23% higher, and the 15 year rate was 46% higher. These differences are viewed as significant, given that this range for INTR is meant to represent a realistic range for INTR values. This is a significant result for an uncontrollable variable.

In the wider range of 0 to 1.0 INTR, simulation runs demonstrated that the results in the areas of reducing the number of multi-party customers, and the capital investment required, were consistent with the narrower experimental range discussed above. Throughout this range, the number of multi-party customers was reduced to zero in year 10, the same as the base run. The peak investment occurred in year nine throughout this range, and the peak amount was constant at $207.80 million for all runs except the 1.0 value for INTR. For this run, representing a real interest rate of 100%, the peak capital investment was $207.63 million, only a very slight difference. In the area of rates, however, the differences in results were quite large. For the simulation run representing zero interest, the rates in year 20 were $73.67 (or 39%) lower than the base run results. For the simulation run representing 100% interest, the rates in year 20 were $7066.50 (Figure 13).

Figure 13 100% Interest Rate
ANNUAL RATES ($/YEAR)



This experiment indicates that an increase of 11 times in the interest rate resulted in year 20 rates 38 times larger. The fact that the system amplified increases in the interest values in the resulting rates for year 20 indicated a significant system sensitivity to this uncontrollable variable.

7.5 INTERJECTING POLITICAL PRESSURE

The effect of political pressure is modeled by interjecting a random factor of various magnitudes into the rate adjustment process. By using an "amplified" value (i.e., >1) for the Random Factor Switch (RFS) variable, this experiment is able to run simulations under levels of extreme political pressure. The extremes investigated in this experiment are considered as important not only to disclose potential system sensitivities to political pressure, but also to exercise relevant sections of the model.

With all other variables held at the same values used for the base run simulation, the random factor variable which represents political pressure is changed for the simulation runs in this experiment.

- VARIABLE NAME: RFS
- DESCRIPTION: Random Factor Switch
- CATEGORY: Uncontrollable
- INITIAL VALUE (units): 0 (1/year)
- EXPERIMENTAL VALUES: 1, 10, 100, 1000, 10000

The political pressure on rates was the experimental variable for this set of simulation runs. The first simulation run used the model to generate results with the anticipated effect of political pressure "switched on". Subsequently, amplified values of RFS (up to five orders of magnitude) were used to investigate the system simulation results for extreme political pressure. For all simulation runs in this experiment, the number of multi-party customers was reduced to zero in year 10, and the peak capital investment of $207.80 million occurred in year nine. In the area of rates, the results differed widely with different levels of political pressure. These results were expected, since the political pressure that has been modelled was specifically directed toward keeping rates low. Thus, the initial "switching on" of RFS resulted in a very small reduction in rates in year 20 ($186.73 versus $186.81 for the base run). When the RFS value was increased to 100, the resulting year 20 rates were $181.11; for RFS of 1000, rates were reduced to $166.93.

When the value for RFS was increased to 10,000, the simulation results became more interesting. Although this extreme value for RFS had little relationship to reality, the behaviour of the model at this extreme simulation level illustrated some of the limitations of the model, as well as providing a graphic example of the negative effects of political intervention in a primarily economic process. In this simulation, the number of multi-party customers was reduced to zero in year 10, and the peak investment of $207.80 million occurred in year nine. These results were the same as in the base run. In the area of rates, however, the extreme political pressure was able to hold the rates to approximately $100 until year 11. After this extended period of low rates, the rapidly increasing financial requirements overwhelmed even the extreme political pressure, and the resulting rates ($1.2 million in year 12) demonstrated the urgency of the financial situation. The model was not able to handle the extreme values involved with such an economic shock, and the simulation run "blew up" through exponent overflow at the run time of 12.56.

7.6 CHANGING EQUIPMENT COSTS

Some recent developments in basic telephone access technology, such as the progress in digital radio-based subscriber access systems, have the potential to reduce the average per-customer incremental cost of providing single-party service. This experiment is designed to investigate system behaviour under such changing conditions for the cost of equipment. The advertised cost advantage for a particular commercial example of such technology over conventional hard-wired access technology is from two-to-one to five-to one. As a result, per-customer costs in this range are used in the experiment to simulate the substitution of such lower cost technology. Of course, the technical merits of this new technology have not been proven to the satisfaction of technical network planners at this time, so the adoption of this technology by telephone companies is not a certainty. However, the potential savings from adopting this technology should ensure that the necessary evaluations are completed rapidly. The potential effects on the system of adopting the lower cost technology are therefore examined in this experiment. A marginal increase in equipment costs is also investigated in this experiment to discover any anomalies in system behaviour due to increasing costs of equipment.

With all other variables held at the same values used for the base run simulation, the per customer cost of equipment is changed for the simulation runs in this experiment.

- VARIABLE NAME: ECPC
- DESCRIPTION: Equipment Cost Per Customer
- CATEGORY: Semi-controllable
- INITIAL VALUE (units): 8621 ($/customer)
- EXPERIMENTAL VALUES: 1000, 2000, 5000, 10000

Although the average incremental equipment cost per customer (ECPC) has been considered essentially uncontrollable, there are aspects of this variable that warrant the consideration of decision makers. As discussed in Section 5.1, technological innovation has the potential to drastically reduce the cost of the required equipment. The results of this experiment may then become the guidelines for evaluating the impact of the early adoption of the newer technology. This potential flexibility in ECPC has necessitated the consideration of this variable as semi-controllable. For all the simulation runs in this experiment, the number of multi-party customers was reduced to zero in year 10. The peak capital investment required occurred in year nine in all simulation runs, and the amounts for the peak were directly proportional to the amount of ECPC. For example, the ECPC amount of $1000 represents 11.6% of the base run amount ($8621); and, the resulting peak investment of $24.104 million represents 11.6% of the base run peak of $207.80 million (Figure 14). Similarly, the resulting peak investment for ECPC of $10,000

Figure 14 ECPC = $1000
CAPITAL INVESTMENT ($ million)

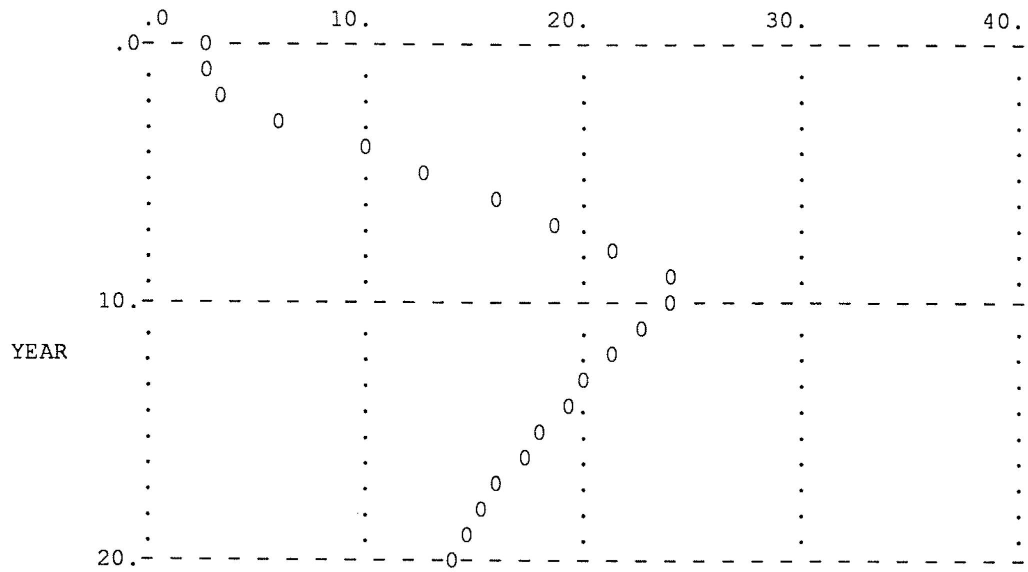
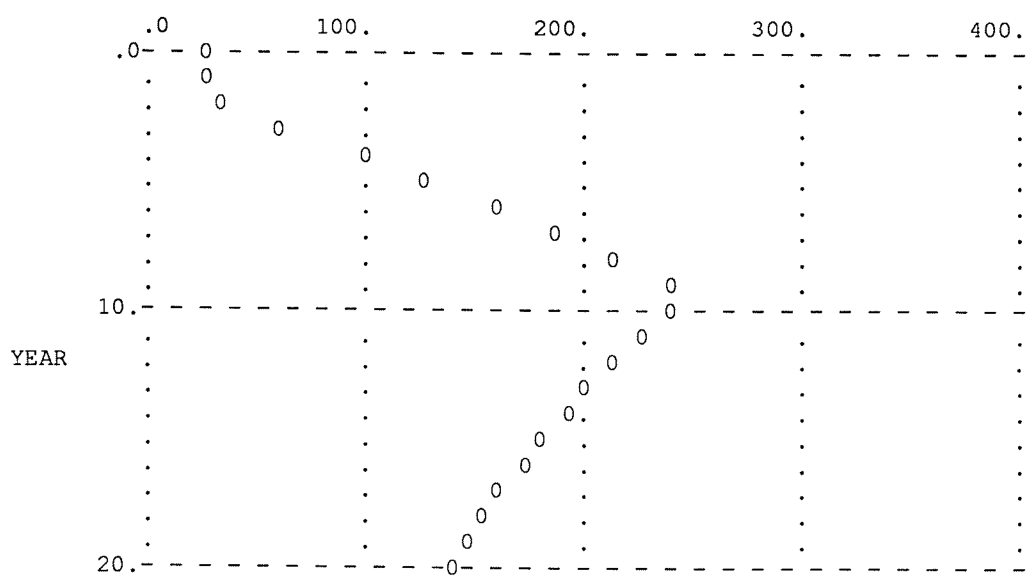


Figure 15 ECPC = $10000
CAPITAL INVESTMENT ($ million)



(116% of base run value) was $241.04 million, or 116% of the base run peak investment (Figure 15).

In the area of rates, however, the results were less directly related to the values used for ECPC. For example, with an ECPC value of $1000 (11.6% of base run value), the rates were 76% of the base run amount in year 10; 61% in year 15; and, 55% in year 20 (Figure 16). Similarly, with an ECPC value of $10,000 (16% increase over base run value), the rates were increased by 5% over the base run amount in year 10; increased by 11% in year 15; and, 13% in year 20 (Figure 17). The movement of the rates over time as a result of different ECPC simulation runs therefore appeared to be in the expected direction, but the resulting rate values were not directly proportionate to the experimental values of ECPC. The increased value for ECPC (16% increase) was more closely matched by the increased amount for year 20 rates (13% increase) than the reversed case of decreased ECPC. For example, with ECPC value decreased to 58% of the base run amount, the resulting year 20 rates were 71% of the base run amount. Also, as previously described, with ECPC value decreased to 11.6% of the base run amount, the resulting year 20 rates were 55% of the base run amount. This indicates that the system showed a lack of flexibility in reflecting savings in equipment costs by proportionate reductions in rates. At the same time, increased equipment costs were able to be reflected in nearly proportional rate increases by year 20.

Figure 16 ECPC = $1000
ANNUAL RATES ($/YEAR)

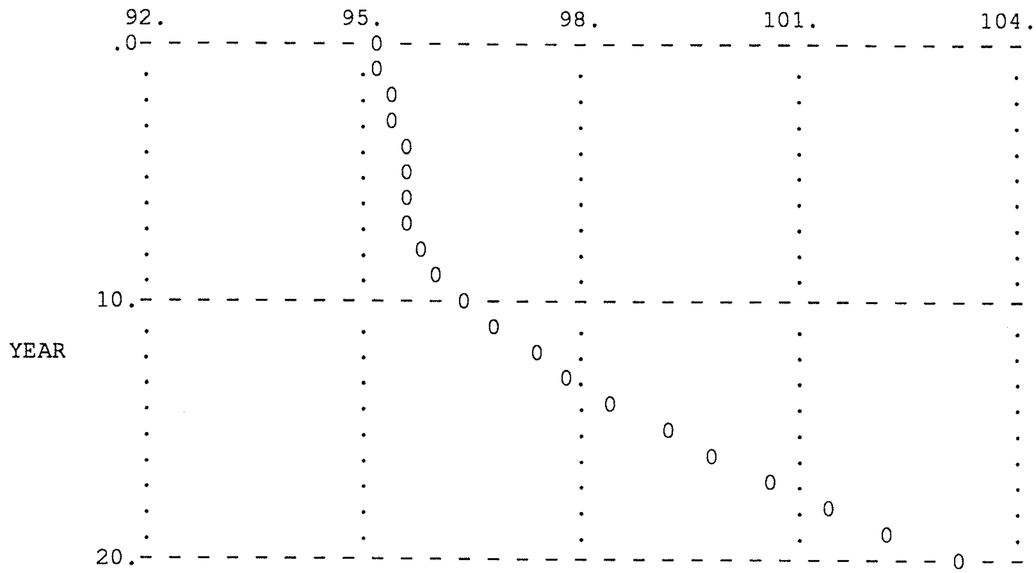
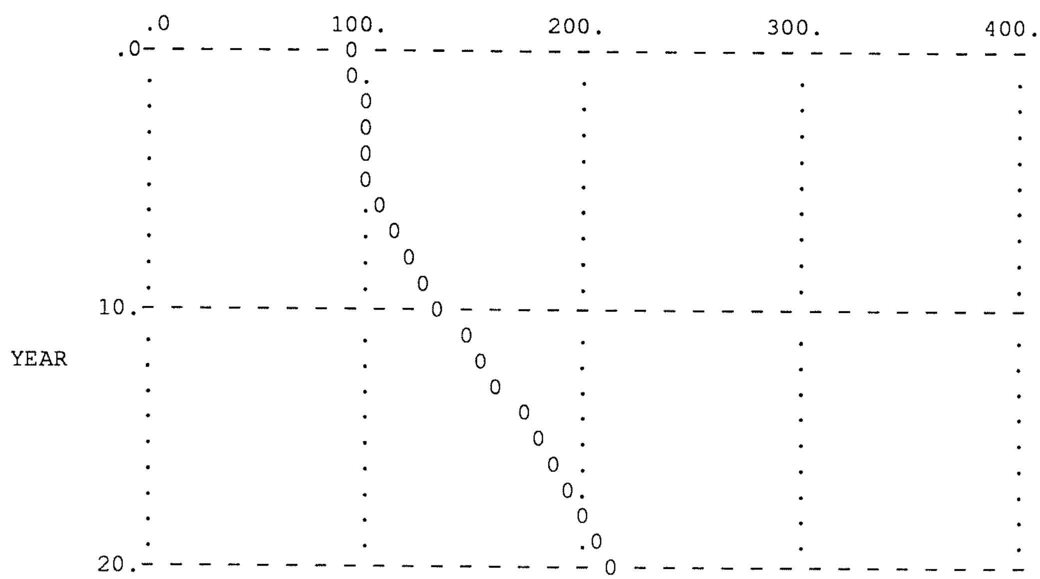


Figure 17 ECPC = $10000
ANNUAL RATES ($/YEAR)



7.7 VARYING PREMIUM SERVICE CUSTOMER CHARGE

This set of simulation runs represents the first experiment in the series related to a controllable variable. In this case, the amount of the initial charge to customers for voluntary conversion to single-party service (PSCC) may be changed by decision makers at MTS. Although Public Utility Board approval would be required for such a change, a viable range for managerial decision making regarding this variable seems possible. This experiment is run with input variable levels within the range of amounts that may be considered politically feasible, based upon the current level. In addition, simulations are run with much lower values for this variable, in order to examine system responses to large decreases in the amount of this charge.

With all other variables (except TSUP - discussed below) held at the same values used for the base run simulation, the premium service customer charge is changed for the simulation runs in this experiment.

- VARIABLE NAME: PSCC
- DESCRIPTION: Premium Service Customer Charge
- CATEGORY: Controllable
- INITIAL VALUE (units): 515 ($)
- EXPERIMENTAL VALUES: 600,500,400,300,200,100,50,25

This experiment represents the first experiment involving changes to a controllable variable. In order to simulate the results of applying a premium service program, instead of a universal program, or mixture of the two programs, the universal program variable for the time of start of the universal program (TSUP - the run time at which the universal program would begin) is set to 21. Thus, all multi-party conversions during the 20 year simulation runs occur as a result of the premium service program conversions.

With the PSCC set to $600, the simulation results indicated that only 2949 multi-party customers (or 6%) were converted to single-party service by year 20. The required capital investment for this option showed increases every year, reaching $53.967 million in year 20. The resulting rates in year 20 were $127.80 (compared to $186.81 for the base run). At $200 PSCC, 19005 multi-party customers (or 41%) were converted by year 20, with a year 20 investment of $132.11 million, and rates of $162.43.

With PSCC set to $100, 36174 (or 78%) of multi-party customers were converted by year 20. The required capital investment increased every year, reaching $215.47 million in year 20 (compared to the $207.80 million peak in year nine for the base run). The resulting rates of $207.23 in year 20 also exceeded the year 20 rates ($186.81) for the base run. At a PSCC value of $50, only 1854 multi-party customers remained in year 20. The required investment also increased every year to reach $257.14 in year 20. The resulting rates in year 20 were $232.82 (25% higher than the base run value). When the value of PSCC was reduced to $25, the number of multi-party customers was reduced to zero within the simulation time - at year 20. The peak capital investment of $270.80 million (30% larger than the base run peak) occurred in year 19. The resulting rates in year 20 were $246.37, compared to $186.81 for the base run. The reason that the premium service programs show higher costs than the universal programs relates to the equipment cost savings involved with converting an entire area at one time (under universal programs), compared to custom installation for each customer converted (under premium service programs). This is reflected in the economies of scale (EOS) factor, which is discussed in Section 5.2.

7.8 UNIVERSAL PROGRAM OPTIONS

Another set of "control levers" available to MTS decision makers relates to decisions concerning the implementation of a non-voluntary, universal program to convert existing multi-party customers to single-party service. Since such a program has already been announced (MTS 1988), decisions that may realistically be changed relate to timing the initiation of the universal program (TSUP), as well as the number of years to be spent in completing the program (USPY). The range over which these variables are actually able to be changed by MTS decision makers is not clear-cut. It is quite unlikely that major changes from the announced timing for the program could be initiated; however, the system effects of widely varying changes are of interest from an experimental perspective. For this experiment, therefore, implementation of the universal program at varying combinations of initiation times and completion schedules, is simulated.

With all other variables held at the same values used for the base run simulation, the variables representing the durations and starting times for universal programs are changed for the simulation runs in this experiment.

- VARIABLE NAME: TSUP
- DESCRIPTION: Time of Start of Universal Program
- CATEGORY: Controllable
- INITIAL VALUE (units): 2 (years)
- EXPERIMENTAL VALUES: 0, 5, 10, 15

- VARIABLE NAME: USPY
- DESCRIPTION: Years to Complete Universal Program
- CATEGORY: Controllable
- INITIAL VALUE (units): 7 (years)
- EXPERIMENTAL VALUES: 5, 10, 15, 20

This experiment represents the evaluation of a number of universal program options. Two variables were involved in this experiment: the time that the universal program starts (TSUP); and, the number of years that the program takes (USPY) to reduce the number of multi-party customers to zero. Since both of these variables are controllable, the results of these simulation runs offer some insight into favourable universal program implementations.

In terms of reducing the number of multi-party customers to zero, all the universal programs modelled in this experiment seemed to accomplish their stated objectives fairly well. Thus, the five year program beginning in year zero reduced the number of multi-party customers to zero in year six (Figure 18). Similarly, the ten year program beginning in year five reduced the number of multi-party customers to zero in year 16. Also, the 20 year program beginning in year zero reduced the number of multi-party customers to 3554 in year 20, and should have reached zero shortly thereafter (Figure 19). As expected, a large number of multi-party customers (30573) remained in year 20 for the 15 year program beginning in year 15.

In the area of the required capital investment, a number of general observations were possible. All five year programs had a higher required peak investment than in the base run results. Thus, the five year program beginning in year five had a peak of $222.12 million in year ten, compared to $207.80 in year nine for the base run. Also the five year programs that started later in the simulation had higher peaks than programs with earlier starts. For example, the five year program beginning in year ten had a peak of $225.71 million in year 15, compared to the program beginning in year zero, which had a peak of $215.95 million in year five. For the ten year programs, the peak values were all lower than the base run value. As an example, the ten year program beginning in year five had a peak value of

$194.54 million in year 16 ($207.80 in year nine for the base run). Also, as demonstrated for the five year programs, the ten year programs that started later in the simulation had higher peaks than programs with earlier starts, although the relative differences were smaller in the case of the ten year programs. For example, the ten year program beginning in year ten had a peak of $196.25 million in year 20, compared to the program beginning in year zero, which had a peak of $190.84 million in year 11. Based upon the results observable within the simulation time, the 15 year programs had lower peak values than the ten year programs.

Figure 18 5 Year USP, Starting in Year 0
NUMBER OF MULTI-PARTY CUSTOMERS (1000s)

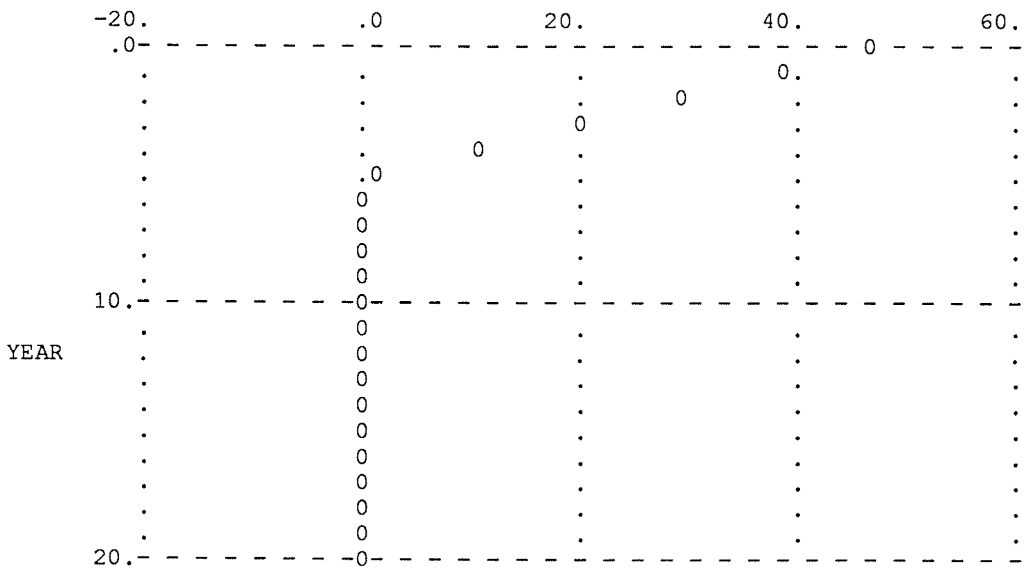
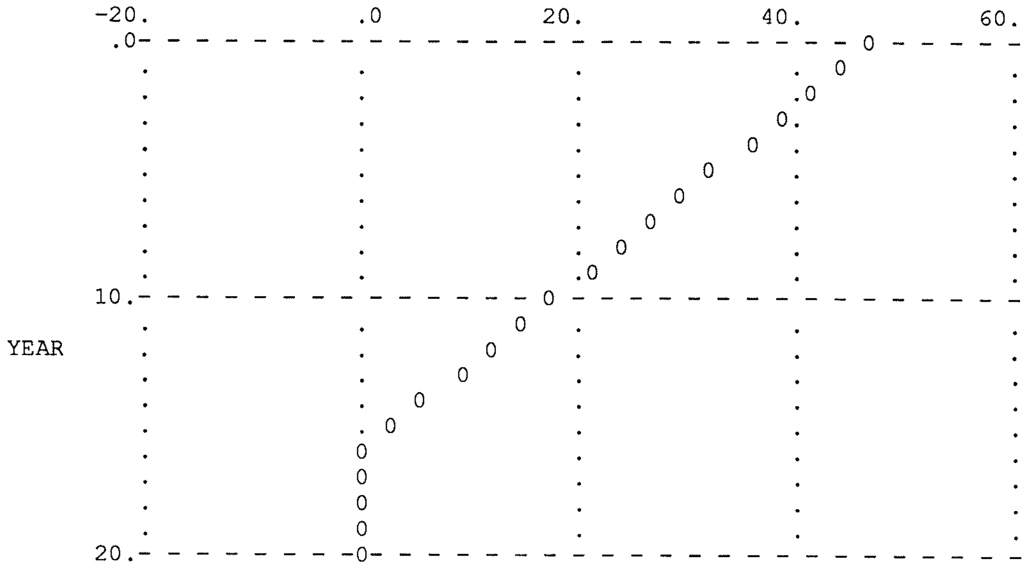


Figure 19 20 Year USP, Starting in Year 0
NUMBER OF MULTI-PARTY CUSTOMERS (1000s)



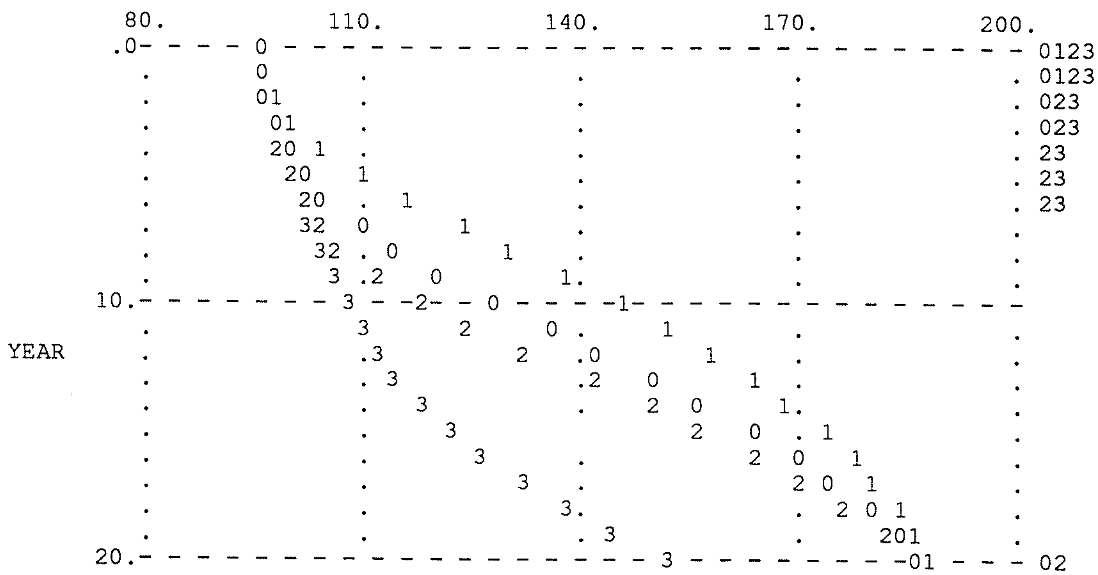
The 15 year program beginning in year zero had a peak value of $172.08 million in year 16 (compared to $190.84 million in year 11 for the ten year program). Similarly, the one 20 year program that nearly completed within the simulation time (starting in year zero), had a peak investment of $147.54 million in year 20, substantially lower than the similar peak required for the 15 year program ($172.08 million in year 16).

In general, the peak capital investment occurred very close to the time (within one year) at which the number of multi-party customers reached zero. The programs with the lowest peak investment values were shown to be those programs with the longest durations and the earliest starts. The total expenditure for equipment must be similar in all programs to convert the same number of customers, since the amount was essentially the ECPC amount multiplied by the number of customers. The differences in peak investment have apparently been caused by the longer timing of some programs, allowing earlier equipment purchases to be depreciated before the investment peak was reached.

The 20 year rate results for the five year program beginning in year zero ($187.64) were slightly higher than the base run value ($186.81). The year 20 rates for the five year program beginning in year five ($186.96) were very slightly higher than the base run value. All the other program combinations considered in this experiment had lower resulting rates in year 20 than the base run. However, since many of these programs required capital expenditures well beyond the simulation time horizon, and such increased investments would be reflected in higher rates only after some delay, the eventual impact of many of these program combinations upon rates would not be seen until well past the simulation time horizon. Shorter duration programs with earlier starting times do not necessarily increase rates to a substantially higher eventual rate than less ambitious programs. As an illustration, in Figure 20 the rate results for three program combinations have been compared to the base run. As expected, the shortest program (five year) with the earliest start (year zero) showed rates increasing more rapidly than other programs, but the curve had "flattened" by year 20. Thus, the nearly complete convergence of the two illustrated five year programs with the base run results by year 20 indicated that the total cost of converting all multi-party customers may eventually result in very similar rates, no matter what timing has been chosen for the expenditures.

The third program with results illustrated in Figure 20 was the ten year program beginning in year ten. This progran showed much lower rates through the simulation time; however, by year 20, the increased slope of this program's rate results, coupled with the decreased slopes for the other programs' rate results, indicated that these rates may all become much closer just beyond the simulation time horizon.

Figure 20 USP Program Options
ANNUAL RATES ($/YEAR)



Base Run=0 USP5/0=1 USP5/5=2 USP 10/10=3

7.9 WORST CASE SCENARIO

A variety of input factors, identified as sensitive, are combined into one experiment to examine the cumulative effects of a number of adverse conditions. It is especially important to determine through such a simulation if the cumulative effects represent geometrically increasing scales, or whether the system behaviour presents natural upper limits which tend to prevent one adverse variable from amplifying the adverse effects of another variable. The worst case scenario simulated in this experiment addresses these concerns by combining unfavourable, but realistic, values for a number of sensitive variables into one simulation. This experimental set of simulations is able to be run based upon initial evaluations of previous experiments to determine the critical variables, and to indicate the relevant adverse values for these variables. In this experiment, then, the "control lever" variables described in sections 7.7 and 7.8 are re-evaluated (e.g., pertinent experimental simulations in 7.7 and 7.8 are re-run) based upon this worst case environmental scenario.

The combination of critical, uncontrollable variables and relevant adverse values used in this experiment is felt to adequately portray a worst case scenario that could be expected within the context of current environmental trends. With all other variables held at the same values used for the base run simulation, values representing the worst, but still realistic levels for critical variables are used for the simulation runs in this experiment.

- VARIABLE NAME: MPG
- DESCRIPTION: Fractional Growth of Manitoba Population
- INITIAL VALUE (units): .0067 (1/year)
- ADVERSE VALUE: .0134

- VARIABLE NAME: INTR
- DESCRIPTION: Interest Rate
- INITIAL VALUE (units): .087 (1/year)
- ADVERSE VALUE: .174

- VARIABLE NAME: ECPC
- DESCRIPTION: Equipment Cost Per Customer
- INITIAL VALUE (units): 8621 ($/customer)
- ADVERSE VALUE: 10000

The decisions to include these specific variables were based upon the criterion that if a variable input value within the realistic range caused an unfavourable result value of more than five percent in one of the critical evaluation factors (see Section 6.2), that variable would be included in the worst case scenario, with the value set to the most unfavourable value within the realistic range.

In the case of population growth (MPG), the simulation runs with double growth values had resulted in year 20 rates six percent higher than those of the base run (Section 7.1). For the interest variable (INTR), the simulation runs with double interest values had resulted in year 20 rates 59 percent higher than those of the base run (Section 7.4).

With respect to the equipment cost variable (ECPC), the simulation runs with $10,000 equipment cost resulted in year 20 rates 13 percent higher than those of the base run (Section 7.6). This was the basis for the inclusion of these three variables, with values set to the most unfavourable levels (indicated above) within the realistic range.

The results for the experimental runs simulating such a worst case scenario showed no significant difference from the base run results in terms of the time to reach zero multi-party customers. As in the base run, NRMP was reduced to zero by year ten.

The required capital investment for the worst case simulation peaked at $249.47 million in year ten (Figure 21). This peak was one year later, and 20 percent higher than the base run results. To place this into perspective, the single variable simulation results of the three worst case variable values were considered. Doubling the population growth resulted in a three percent increase for required capital investment (see Section 7.1). Doubling the interest rate resulted in no increase for required capital investment (see Section 7.4). Increasing the equipment cost to $10,000 per customer resulted in a 16 percent increase in required capital investment (see Section 7.6). The result expected in the worst case simulation, with no compound interactions, was therefore an increase of 19 percent (1.03 * 1.00 * 1.16 = 1.19). Since the worst case simulation investment result showed an increase of 20 percent, the combined effect of the three variables in this experiment was not significantly different from combining the results of the individual variable simulation runs.

Figure 21 Worst Case Scenario
CAPITAL INVESTMENT ($ million)

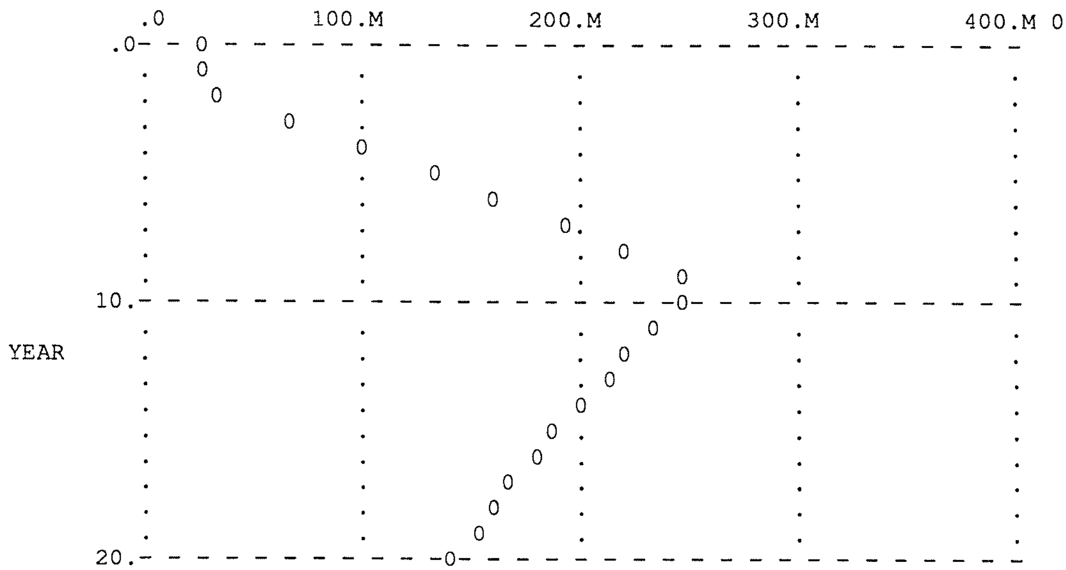
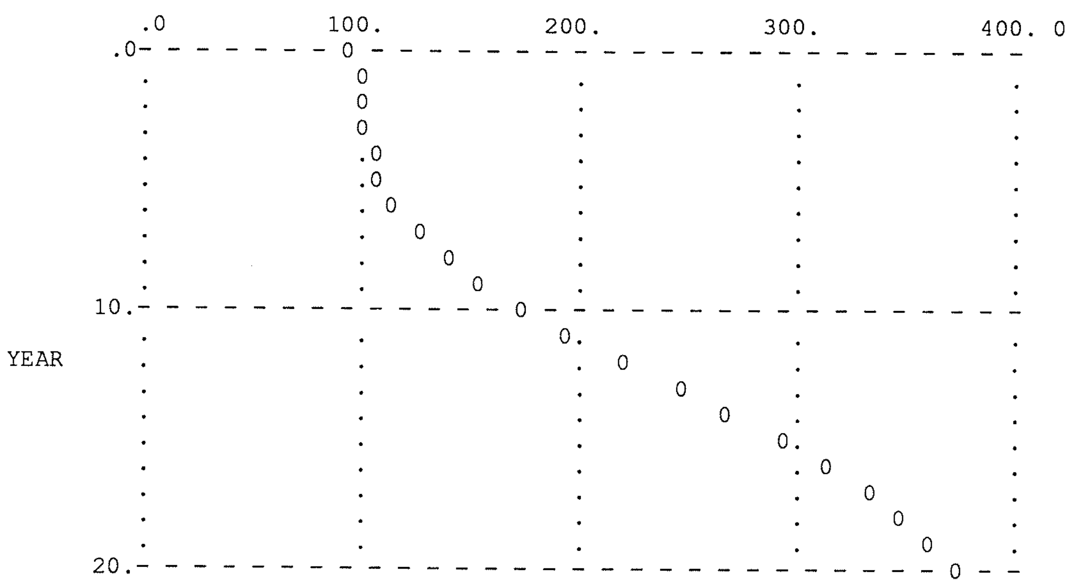


Figure 22 Worst Case Scenario
ANNUAL RATES ($/YEAR)



In the area of rates, however, the results were substantially different (Figure 22). The resulting rates for the worst case simulation were $173.02 in year ten, $290.10 in year 15, and $374.34 in year 20. The year 20 rates were 100 percent higher than the base run rates. In the base run, the rates increased by 28 percent between year ten and year 15; while, the analogous results for the worst case simulation showed an increase of 68 percent. Similarly, for the base run, the rates increased by 14 percent between year 15 and year 20; while, the analogous results for the worst case simulation showed an increase of 29 percent. The single variable simulation results of the three worst case variable values were considered to analyze the cumulative effects of the combination of variables. Doubling the population growth resulted in a six percent increase in year 20 rates (see Section 7.1). Doubling the interest rate resulted in a 59 percent increase in year 20 rates (see Section 7.4). Increasing the equipment cost to $10,000 per customer resulted in a 13 percent increase in year 20 rates (see Section 7.6). The result expected in the worst case simulation, with no compound interactions, was therefore an increase of 90 percent (1.06 * 1.59 * 1.13 = 1.90). Since the worst case simulation 20 year rates result showed an increase of 100 percent, the combined effect of the three variables in this experiment was significantly different from combining the results of the individual variable simulation runs. The undesirable increases in year 20 rates were amplified an additional 10 percent when adverse values for the three worst case variables were allowed to interact in the same simulation run.

CHAPTER 8

CONCLUSIONS

The experimental results discussed in the previous chapter lead to a number of conclusions of relevance to the decisions makers planning such a rural service improvement program for Manitoba Telephone System. In this chapter, these conclusions are discussed, and recommendations are presented.

8.1 BASE RUN CONCLUSIONS

The base run simulation, reflecting the most likely values for system variables, indicated that even though the peak capital investment of $207.8 million occurred in year nine, the increases in rates were greatest after the investment peak. Thus, the percentage increase in rates was greater from year 10 to year 20 (47%) than in the first 10 year period (34%). The overall increase in rates for the 20 year simulation time was 96 percent.

This 96 percent increase in rates (or approximate doubling of real rates) should be considered from a cautionary perspective. This increase is due mainly to the requirements of funding the single-party conversion program, since the system simulation run with no single-party conversion program showed only a 16 percent increase in rates over the 20 year simulation time (from $95.22 to $110.35), due to growth in the number of customers. During this same time period, however, the increasingly competitive environment for the telecommunications industry is expected to exert significant upward pressure on local rates (see Section 5.9) as the subsidies from long-distance revenues are reduced, and local rates are adjusted to be closer to actual costs. Manitoba is seen to be particularly vulnerable to local rate increases in this adjustment process for a number of reasons: (1) local rates for telephone service in Manitoba are among the lowest in Canada, and present indications are for more uniform regulation across Canada (Bill C-41, for example), (2) Manitoba population is clustered into one urban centre (Winnipeg), which precludes the generation of any substantial inter-urban long-distance revenues within the province, and (3) settlement payments for long-distance calls which "pass through" Manitoba are likely to decrease with lower long-distance rates, and the advent of long-distance competition as well as other alternative methods for bypassing the existing public network.

8.2 UNCONTROLLABLE VARIABLES

For most of the uncontrollable variables, the experimental results using variable values within the realistic range did not differ greatly from the base run results.

For population growth, the model was shown to be not particularly susceptible to minor differences in variable values. The percentage of population growth in

Manitoba has been fairly stable over the last several years (see Section 3.2), and there have been no indications that this situation will change in the foreseeable future.

The increase threshold for reaction (INFR) experimental runs showed that even major changes in the value of this variable caused only very small changes in the simulation results. For demand elasticity, only major changes in variable values had a significant effect on experimental results. This variable has been fairly stable over the past decade (see Section 3.3), and the gradual trend of the changes has been in a direction favourable to the objectives of the rural service improvement program.

Political pressure, although highly unpredictable in the shorter term, was shown to be unlikely to have significant long term effects on the results of this program. Only very large amounts of sustained political pressure had significant effects on the simulation results, and the political pressure was eventually counteracted by the financial requirements of the system.

The interest rate variable (INTR) was one of the exceptions to the general minimal effects conclusion for uncontrollable variables (see Section 7.4). Changes in the values of this variable had significant effects on the experimental results, particularly in the area of local rates for telephone service. This conclusion is especially disturbing in an environment of increasing interest rates, since experimentally such increases resulted in unfavourable increases in local telephone rates. The increases in experimental results were more sensitive in the upward direction; that is, it was easier for local rates to increase with increased interest rates, than to decrease with decreased interest rates.

The equipment cost variable represented the other exception to the general minimal effects conclusion. As discussed in Sections 5.1 and 7.6, though, the value of this variable may be somewhat controllable through the rapid assessment and early adoption of new technologies, or by engineering improvements in the network design. Equipment cost has therefore been considered a semi-controllable variable. The experimental results indicated that the peak capital investment required was directly proportional to equipment costs. The local rates resulting from changes in equipment costs were not as directly related: with higher costs, the local rates increased faster, and reached proportionately higher values, than was the case with lower equipment costs. This effect was similar to that discussed for increased interest rates, where the increases in experimental rates results were also more sensitive in the upward direction.

8.3 CONTROLLABLE VARIABLES

The premium service options investigated in experimental simulations demonstrated that this range of programs was uniformly ineffective in addressing the critical success factors for single-party conversion (see Section 6.2). This ineffectiveness was especially noticeable in the area of reducing the number of multi-party customers to zero. Even when the customer charge for premium service (PSCC) was reduced to $100 from the base run value of $515, only 78 percent of the multi-party customers were converted by year 20. The peak investment for this partial conversion under the premium service approach was higher than the base run amount ($215.47 million compared to $207.8 million), and the resulting year 20 rates were also higher than those in the base run ($207.23 compared to $186.81). In order to reduce the number of multi-party customers to zero by year 20 (compared to year 10 for the base run), the resulting peak investment was 30 percent higher than the base run amount, and the resulting year 20 rates were 32 percent higher.

The universal program approach offered results that were generally more positive than the premium service approach. The conclusions relating to the universal program approach can be summarized in two statements: (1) shorter duration programs resulted in higher investment peaks than longer duration programs, and (2) programs which started earlier in the simulation period resulted in lower peak investments than those programs with later starting times.

Since the universal program with seven year duration that was modelled in the base run has been publicly announced, only a limited amount of decision flexibility remains. For example, the extension of the program duration to eight years may be publicly justifiable, given extenuating circumstances (such as rising interest rates). With substantial increases in real interest rates, for example, extension of the program duration to 10 years may be acceptable.

8.4 COMBINATIONS OF VARIABLES

For the worst case scenario (Section 7.9), the combination of unfavourable values for fractional growth of Manitoba population (MPG), interest rate (INTR) and equipment cost per customer (ECPC) was shown to result in an amplified increase in rates. This conclusion leads to the possible consideration of selecting different values for controllable variables under adverse conditions for uncontrollable variables. Interest rates have been highlighted as the most likely uncontrollable variable to have a significantly adverse effect on program results. The extension of program duration time for the universal program to offset the adverse effects of increased interest rates was discussed above. Another combination approach (discussed in Section 8.2) is to reduce the equipment costs to offset increasing interest rates.

8.5 RECOMMENDATIONS

The wisdom of the decision to proceed with a universal program (as opposed to the premium service approach) for single-party conversion has been well-supported by the results of the experimental simulations using the system model. The longer-term effects of such a program on local rates have not been widely discussed, but the experimental results clearly indicate substantial increases in local rates.

The first priority recommended for Manitoba Telephone System in implementing this rural service improvement program is to reduce the cost of equipment required. As discussed in Section 5.1, the value used for equipment cost has been extracted from program announcements and other Manitoba Telephone System statistics. This value is substantially higher than industry standard values for similar construction programs, so cost improvement may be possible through the re-examination of network engineering alternatives. In addition, one new technology that could possibly be used to lower the equipment cost has also been discussed in Section 5.1. It would be quite beneficial to expedite the technical evaluation and field trial of this system, since the potential savings for the entire single-party program are substantial. Such savings would be particularly noticeable in conjunction with adverse values for other variables. As an example, Figure 23 depicts the rates resulting from a 30 percent decrease in equipment cost and a 40 percent increase in interest rate. In this case, the local rates after 20 years were only 90 percent of those in the base run, compared to 121 percent when just the interest rate was increased 40 percent. With lower interest rate increases, reduced equipment costs still resulted in lower long-term rates. For example, a 30 percent reduction in equipment costs with a 10 percent increase in the interest rate resulted in year 20 local rates 19 percentage points lower than those in the base run.

Figure 23 30% Decreased ECPC, 40% Increased INTR
ANNUAL RATES ($/YEAR)

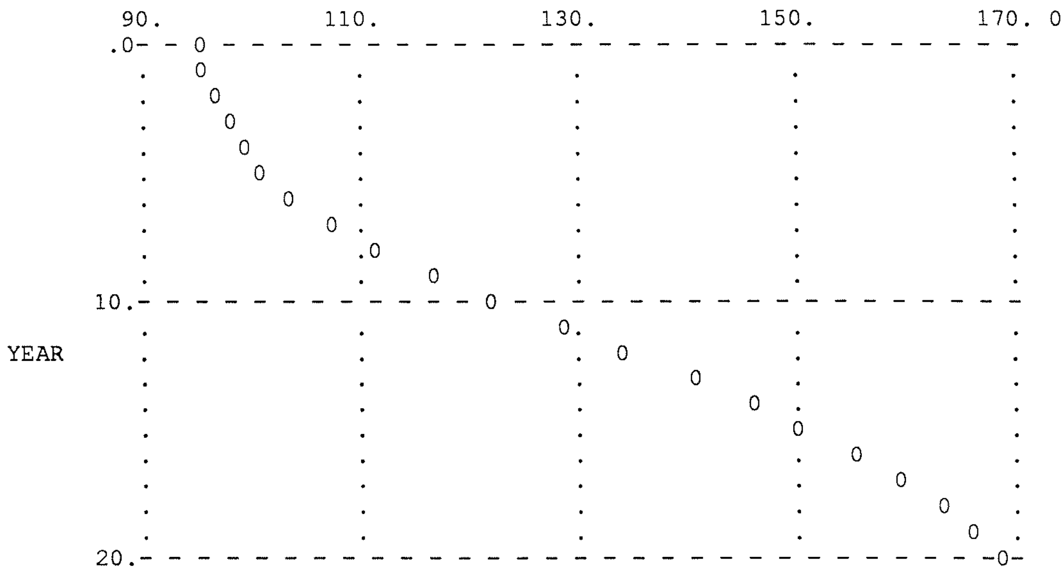
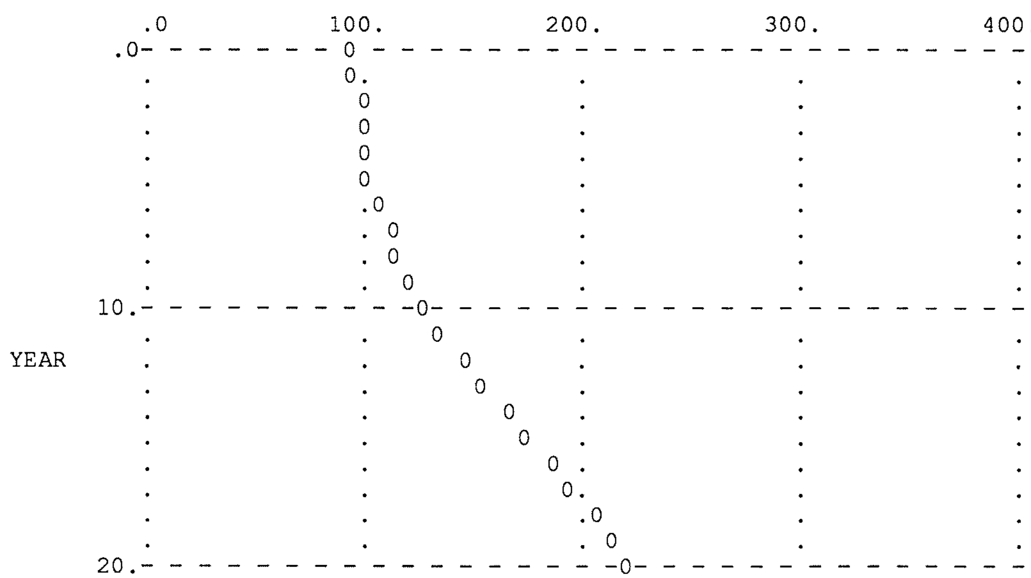


Figure 24 10 Year USPY, 40% Increased INTR
ANNUAL RATES ($/YEAR)



Increasing the duration of the universal program in response to adverse values for uncontrollable variables is recommended as a useful approach toward moderating the undesirable effects of the uncontrollable adverse values. For example, with an experimental simulation run using a 40 percent increase in the interest rate, the resulting local rates in year 20 were 21 percent higher than the base run values. By extending the duration of the universal program to 10 years (from the base run value of 7 years), the increase in local rates for year 20 was 17 percent (Figure 24). Of course, the compromise represented by such an extension of the duration of the universal program was that the conversion of all multi-party customers was not completed until year 13 (compared to year 10 in the base run). The capital investment also peaked later (year 13) at $192.58 million (compared to $207.8 million for the base run). Even for a 10 percent increase in the interest rate, the expected increase in year 20 local rates was reduced from five percent to four percent by extending the universal program duration by one year (to eight years). The resulting peak investment of $202.36 occurred in year 10. Achieving a smaller (three percent less in this case) peak investment becomes more important as the cost of financing (interest rate) increases. The recommendation, then, is to index the duration of the universal program to changes in the real interest rate.

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