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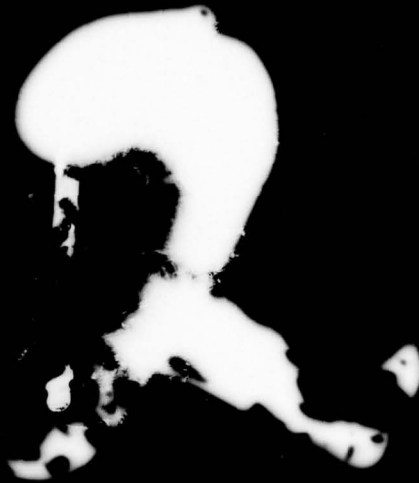
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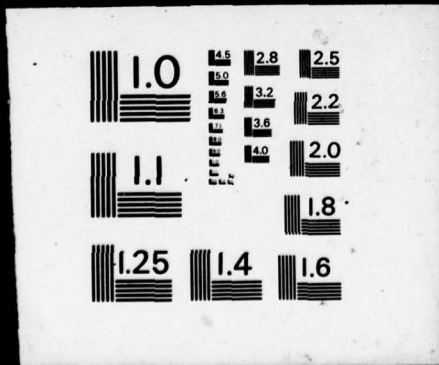
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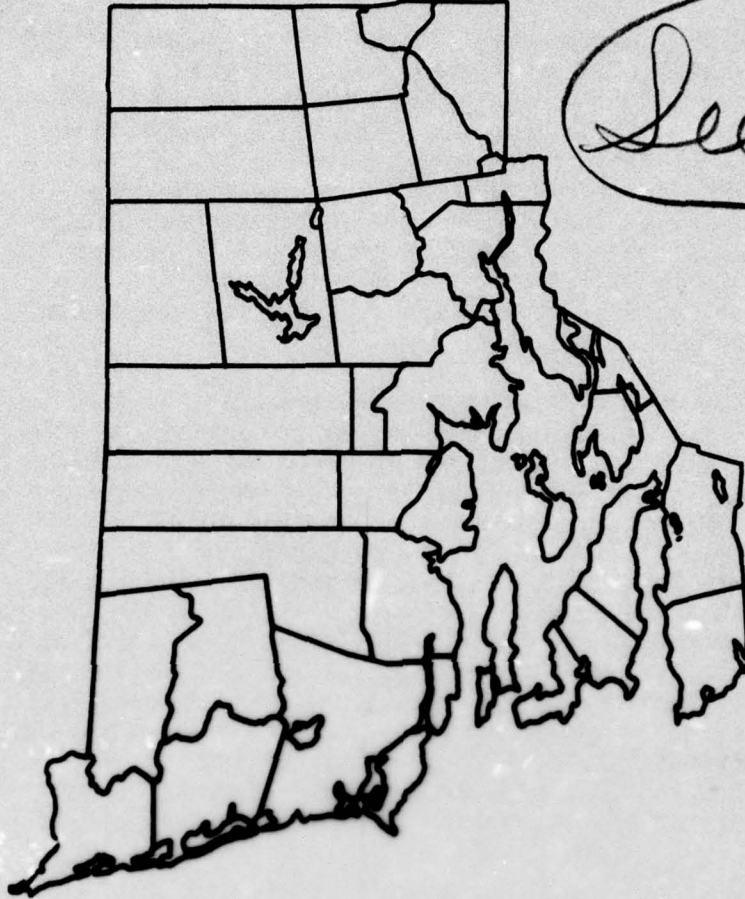
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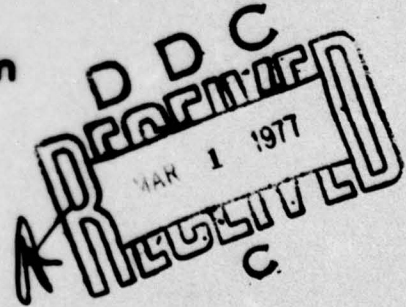
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THE RHODE ISLAND MODEL

A Simulation
Relating the Educational System
to the State Labor Market

S. ERICKSON
J. VENTURA
N. WILSON



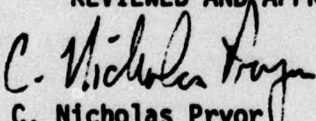
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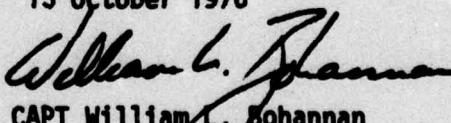
PREFACE

This document was prepared at the Newport Laboratory of the Naval Underwater Systems Center under the Navy's technology transfer program. The project leader for this work was Dr. Stanley Erickson, who was responsible for the model design. Mr. John Ventura was responsible for the implementation of the model on a CDC 3300 computer, and Miss Nancy Wilson, currently at the Wharton School of Business, University of Pennsylvania, provided much assistance in researching and preparing statistical data in the model. All three authors collaborated in testing and refining the simulation, and in preparing this document.

The development of this model owes the most, by far, to Dr. Reo Beaulieu, of the Rhode Island Department of Education Planning Department, who first saw the need for a long-range planning tool such as dynamic modeling, and who arranged for its implementation despite numerous obstacles and objections. Much of this report is his. Mr. Frank Laffey, of the Rhode Island Manpower Department provided considerable information and insight into the model, as did Dr. Daniel E. Koble, Jr. of the Center for Vocational and Technical Education, Ohio State University. The support of the Rhode Island Commissioner of Education, Dr. Thomas Schmidt, was instrumental in carrying the model through to its completion. For the preparation of the final document, the careful technical editing of Mr. Walter Golembewski, of the Naval Underwater Systems Center, Technical Information Department, is especially appreciated.

REVIEWED AND APPROVED: 15 October 1976


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ABSTRACT

The Rhode Island Model described in this document is a prototype simulation of the population and economics of the State of Rhode Island. It focuses specifically on the vocational education programs conducted by the State, their effect on the labor market, and the consequent gains and losses to the State in terms of unemployment and welfare costs. The model completely describes the vocational education system in a mathematical form usable by planners and administrators in the Rhode Island Department of Education and elsewhere. It is designed to clearly indicate, among other things, the approximate effect of State budget allocations on student enrollment, unemployment rates, and State welfare costs. Because the model presented here is an initial prototype, it does not incorporate detailed data from the State which would allow accurate projections. However, it does have the structure to handle such data, and provides estimates for each quantity so that the usefulness of the design can be demonstrated through sample model runs.

The model is designed as a sum of several interconnected sectors. This is done for two reasons. First, a sectorial arrangement is easier to explain, to program, to test and verify, and to use than a non-sectorial arrangement. Second, this arrangement allows a convenient means of expanding the model to cover other areas of state policy amenable to dynamic planning (such as the inducement of economic growth, pollution control, or land use) if such sectors are desired in the future.

The principal sectors of the model discussed in this document are the labor sector, which deals with skilled and unskilled, employed and unemployed workers; the student sector, which describes the enrollment in vocational programs, college preparatory, and other programs at both the high school and junior college level; the student behavioral sector

which estimates the attractiveness of vocational education; and the state budget sector which gives the dollar expenses of the State in various educational categories.

Initial runs of the model, which are made under the assumption that the State does not reallocate funds between budget categories but instead maintains them as they were in 1973, are also displayed. They show a slowing of population growth, rising unemployment, and a saturation of vocational school attendance. Once calibrated against State and National data, this model is intended to be used in the future to influence decision making about such reallocations, so that the trends in State growth can most naturally be aided by the vocational education system.

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GLOSSARY

ADON	Annual dropout rate from the ninth grade
ADORC	Annual dropout rate for college preparatory students
ADORG	Annual dropout rate for general curriculum students
ADORJn	Annual dropout rate in the junior college non-Voc Ed program in the nth year
ADORL	Annual dropout rate for local Voc Ed students
ADORP	Annual dropout rate for post-secondary school students
ADORV	Annual dropout rate for Voc Ed students in area schools
ANESF	Increase in the fraction of women employed in skilled jobs
ANEUF	Increase in the fraction of women employed in unskilled jobs
AP	Academic prejudice
APUL	Average family size of unskilled, unemployed workers
APUW	Average family size of unskilled, employed workers
APSL	Average family size of skilled, unemployed workers
APSW	Average family size of skilled, employed workers
ATIME	Psychological response time of students to policy changes
ATP	Adult training programs
AVF	Fraction of ninth-grade students entering area schools
AVSG	Area Voc Ed students graduating
AVSn	Area Voc Ed students in the nth grade

GLOSSARY (cont'd)

CLSIZ	Class size
CM	Career motivation (may be suffixed with "A" or "P")*
COSTS	First approximation of the true burden of unemployment to the State
CP	Total potential capacity of Voc Ed schools
CPF	Fraction of students in the college preparatory program
CPSG	College preparatory students graduating
CPSn	College preparatory students in the nth grade
CR	Crowding ratio
CT	Competency of teachers (may be suffixed with "A" or "P")
DCAP	Designed capacity of schools (may be suffixed with "A" or "P")
DELAY	Time lag used when information is not immediately available
DR	Death rate
EEVER	Expense incurred by employers in support of student morale (may be suffixed with "A" or "P")
EQPN	Normal expense for equipment
ETIME	Average time span for peer-group influence
ESM	Employer support for student morale
ESW	Employed, skilled workers
EUW	Employed, unskilled workers
FOTTES	Fraction of workers from other training tracks finding employment as skilled workers
FSCP	Fraction of students allowed to enter co-op training programs
GCF	Fraction of students in the general curriculum program
GCSG	General curriculum students graduating
GCSn	General curriculum students in the nth grade
GRR	Graduation rate for area schools and junior college
HNSW	Fraction of general curriculum program graduates or drop-outs from high school or junior college not seeking work

*NOTE: In the text of this document, some of these terms are suffixed with either "A" or "P". This indicates that the term in question refers (respectively) either to area or post-secondary schools only. Rates and values for all terms are given per year.

GLOSSARY (cont'd)

IBSJGR	Fractional increase in employed, skilled workers
IBSJGRVDFG	Growth rate of skilled jobs
IBUJGR	Fractional increase in employed, unskilled workers
IBUJGRVDFG	Growth rate of unskilled jobs
JCTYPF	Fraction of students in the junior college two-year program
JCVFC	Fraction of college preparatory curriculum students entering the junior college vocational program
JCVFG	Fraction of general curriculum students entering the junior college vocational program
JCVFL	Fraction of local vocational students entering the junior college vocational program
JCVFV	Fraction of area Voc Ed students entering the junior college vocational program
JCVSG	Junior college vocational students graduating
JCVSn	Junior college vocational students in the nth grade
LVF	Fraction of ninth-grade students entering local vocational schools
LVSE	Locally supported Voc Ed students
LVSG	Local Voc Ed students graduating
LVSn	Local Voc Ed students in the nth grade
LSVE	Locally supported Voc Ed students
LT	Lost time (may be suffixed with "A" or "P")
MATN	Materials normally required for each student
MIGR	Migration rate
MLSR	Total Voc Ed students that the local high school districts will support
MR	Maintenance rate (may be suffixed with "A" or "P")
MMR	Minimum maintenance at which a school can continue to function
MSL	Migration of unemployed, skilled labor
MSURS	Measure of State unemployment rate for skilled workers
MSURU	Measure of State unemployment rate for unskilled workers
MSW	Migration of skilled workers
MUL	Migration of unemployed, unskilled labor
MUW	Migration of unskilled workers
NF	Nuisance factors (may be suffixed with "A" or "P")
NSTU	Number of students
NUR	National unemployment rate
OA	Overall attractiveness
OAA	Overall attractiveness as expressed by the fraction of students willing to apply to area schools

GLOSSARY (cont'd)

OAP	Overall attractiveness as expressed by the fraction of students willing to apply to post-secondary schools
OTT	Other training tracks
OTTDHN	Fraction of high school dropouts entering other training tracks
OTTDJN	Fraction of junior college dropouts entering other training tracks
OTTHN	Fraction of general curriculum graduates entering other training tracks
PA	Program applicants
PEN	Past enrollment
PEN/CP	Peer group factor (may be suffixed with "A" or "P")
PEQP	Propriety of equipment (may be suffixed with "A" or "P")
PLE	Placement effectiveness
POP	Population
PRE	Public relations expense (may be suffixed with "A" or "P")
PSUR	Perceived skilled worker unemployment rate (may be suffixed with "A" or "P")
PSW	Perceived starting wages (may be suffixed with "A" or "P")
PTIME	Notation for time delay
PSJO	Perceived skilled job opportunities
PUR	Perceived unemployment rate
PUUR	Perceived unskilled worker unemployment rate
PWR	Perceived wage ratio (may be suffixed with "A" or "P")
QT	Quality of training (may be suffixed with "A" or "P")
RIPOP	Rhode Island population
RIPOPGR	Rhode Island population growth rate
RIPOPMIGR	Rhode Island population migration rate
RRSN	Average rate of skilled workers' attrition
RRUN	Average rate of unskilled workers' attrition
RSLOT	Persons enrolled in full-time training programs
RSW	Retirement (or other attrition) of skilled workers
RUW	Retirement (or other attrition) of unskilled workers
SAT	Tuition cost borne by the State
SAW	Skilled worker average wage
SCALF	Constant used to scale variable CM to yield the desired value of OA in the year 1972 (may be suffixed by "A" or "P")
SEEQP	State expenditure for equipment per student
SEF	Self-esteem factors
SEIST	State expenditure per student for in-service training of teachers

GLOSSARY (cont'd)

SEM	State expenditure for morale
SEMAT	State expenditure for materials per student
SEMT	State expenditure for maintenance per student
SEPR	State expenditure for public relations per student (may be suffixed with "A" or "P")
SETR	State expenditure per student for transportation (may be suffixed with "A" or "P")
SPE	State expenditure per student for placement of graduates
SJO	Skilled job openings
SMAT	Sufficiency of materials
SSM	State support for morale (may be suffixed with "A" or "P")
STUn	Students in the nth grade
SUR	State unemployment rate
SURS	State unemployment rate for skilled workers
SURU	State unemployment rate for unskilled workers
SWG	Starting wage for graduates
TADH	Total annual dropout rate for high school students
TADP	Total annual dropout rate for post-secondary Voc Ed students
TADJG	Total annual dropout rate from junior college general curriculum students
TADP	Total annual dropout rate for post-secondary school students
TBC	Textbook cost
TC	Tuition cost
TNGP	Total ninth grade population
TOBS	Replacement time for equipment
TUITION	Total cost required to operate a school per student
TUSL	Transfer of skilled labor to unemployable status
TUSLN	Fraction of skilled labor acquiring unemployable status
TUUL	Transfer of unskilled labor to unemployable status
TUULN	Fraction of unskilled labor acquiring unemployable status
TVEE	Total Voc Ed student enrollment (may be suffixed with "A" or "P")
UAW	Unskilled worker average wage
UHS	Unskilled youth entering the labor market
UJO	Unskilled job openings
UPE	Upgrading of workers
UR	Unemployment rate
USLP	Unemployed, skilled labor pool
UUPL	Unemployed, unskilled labor pool
VEIS	Voc Ed image in the State administrator's view (may be suffixed with "A" or "P")

CHAPTER 1

INTRODUCTION

As society becomes more complex and more technologically oriented, the problems of creating and maintaining a competent work force become more and more severe. Technological changes create demands for new types of skills while diminishing or eliminating the demand for others. The less-educated and unskilled find themselves increasingly handicapped in the labor market as demand grows for higher levels of skill. There exists a "manpower paradox" - some workers are without jobs at the same time that jobs are unfilled because of a shortage of qualified workers.

To meet these growing educational and economic problems, numerous manpower and vocational education policies have been implemented at the National and State levels. Now, however, there exists a multiplicity of funding sources, training programs, planning staffs, and decision makers, whose efforts are often uncoordinated. This lack of coordination exists between local, Federal, and State levels of government, within any one level, and within various independent agencies. For example, manpower training involves the Federal departments of Health, Education and Welfare, Housing and Urban Development, Agriculture, Labor, Interior, and Defense. Funds for State-run vocational training schools are derived from all three levels: local, State, and Federal.

In addition, there is a multiplicity of channels through which individuals can acquire job skills. Besides the several federal manpower training programs and State vocational education schools, there are vocational education programs in public secondary schools for both school age and adult attendees. There are also junior colleges, trade and business apprenticeship programs, specialized schools such as those attached

to hospitals, not to mention the huge training programs of the military services. In the absence of guidelines and coordination, decisions made by different supporters of vocational education may result in not only duplication of effort, but also in misplacement of valuable training resources.

Today, the planning of these various training channels is carried out in institutions and agencies with widely differing goals and responsibilities. It is not unusual for each institution to produce "comprehensive master plans" without taking those of other institutions into account. Usually those involved have developed neither channels of communication nor an awareness of the close interrelated nature of one another's problems. If there are any contacts at all they are mostly on an ad hoc, informal, and personal basis. Furthermore, economic development and planning is yet another autonomous function of the State government, even though economic development will create needs for educational training and will draw on the graduates of training programs as a base for further industrial and service growth. The planning of the various types of training and economic development programs could only be helped by increased interaction between the agencies involved.

Experience with other simulation models in many other fields (for instance, the highly-regarded Susquehanna River Basin Model ¹ for regional economic planning) indicates that they can be extremely useful in the role of increasing interagency communication. It was the purpose of this project, as sponsored by the Rhode Island Department of Education, to provide the first step toward the creation of a model useful to planners in all of the previously mentioned fields. Typically, a simulation model not only provides a medium for interagency communication, but also does much more:

1. The model produces clear insight into the structure and behavior of complex educational systems. As has been indicated in industrial and other models, highly complicated systems often act in ways that would be difficult to predict intuitively; often in the inverse of what might be initially expected. But once the system's behavior as conditioned by its structure is understood, it is possible to see how most effectively to use the system to produce the results most desired.

2. The model provides a means of assessing the impact of alternative policies or structural changes in the behavior of the entire system in a matter of minutes. Thus, for planning purposes, a host of possibilities can be visualized and examined with much less effort and less cost than ever before.

3. The model is a means for better long-term prediction of the requirements for and consequences of training plans in effect today. Funds that will be needed in the future, staff requirements, facilities, and so on, can be projected for several years. More importantly, side-effects of a program, small and unnoticeable at first, but which become significant several years hence, can be foreseen and accommodated.

4. The model is a tool for analyzing the effects of external changes. As the outstanding example, effects of the removal of most of the naval forces from Rhode Island can be simulated easily and conveniently. A sophisticated model could estimate the influence of nationwide recession, for instance, and suggest the best way in which the Rhode Island educational system could be structured so as to minimize the ill-effects of such a recession on its citizens.

CHAPTER 2

VOCATIONAL EDUCATION IN RHODE ISLAND

In the state of Rhode Island, vocational education is funded and controlled differently from non-vocational high school programs. College preparatory and general curriculum programs are organized, controlled, and funded by cities and towns individually. In some cities small vocational programs exist within the high schools, although in recent years the number of such programs has been decreasing as more "area schools" have been completed.

These area schools, which are built by the State government and funded by several school districts jointly, are entirely devoted to vocational education. As of the writing of this document, there are nine area schools distributed throughout the State (see figure 1). All but one of these schools are located adjacent to regular high schools and share some administrative facilities, for which the town is reimbursed by the State.

The concept of area schools is relatively new to Rhode Island, having been in existence in the State only since 1965. Each school consists of specialized training stations equipped to teach a particular skill (e.g., welding, machining, electronics assembly or repair, and so on). Each school is designed to serve a certain geographical region within the State, drawing students from several school districts.

Also within Rhode Island is a State-run junior college in which vocational skills as well as college preparatory and other courses are taught. A second junior college with vocational training facilities is also planned. Students may enter the vocational programs from any high school course of study, since the programs are flexibly designed to

accommodate most prior training. Students are required to pay tuition for their education, and are also required to pay for items such as transportation and books.

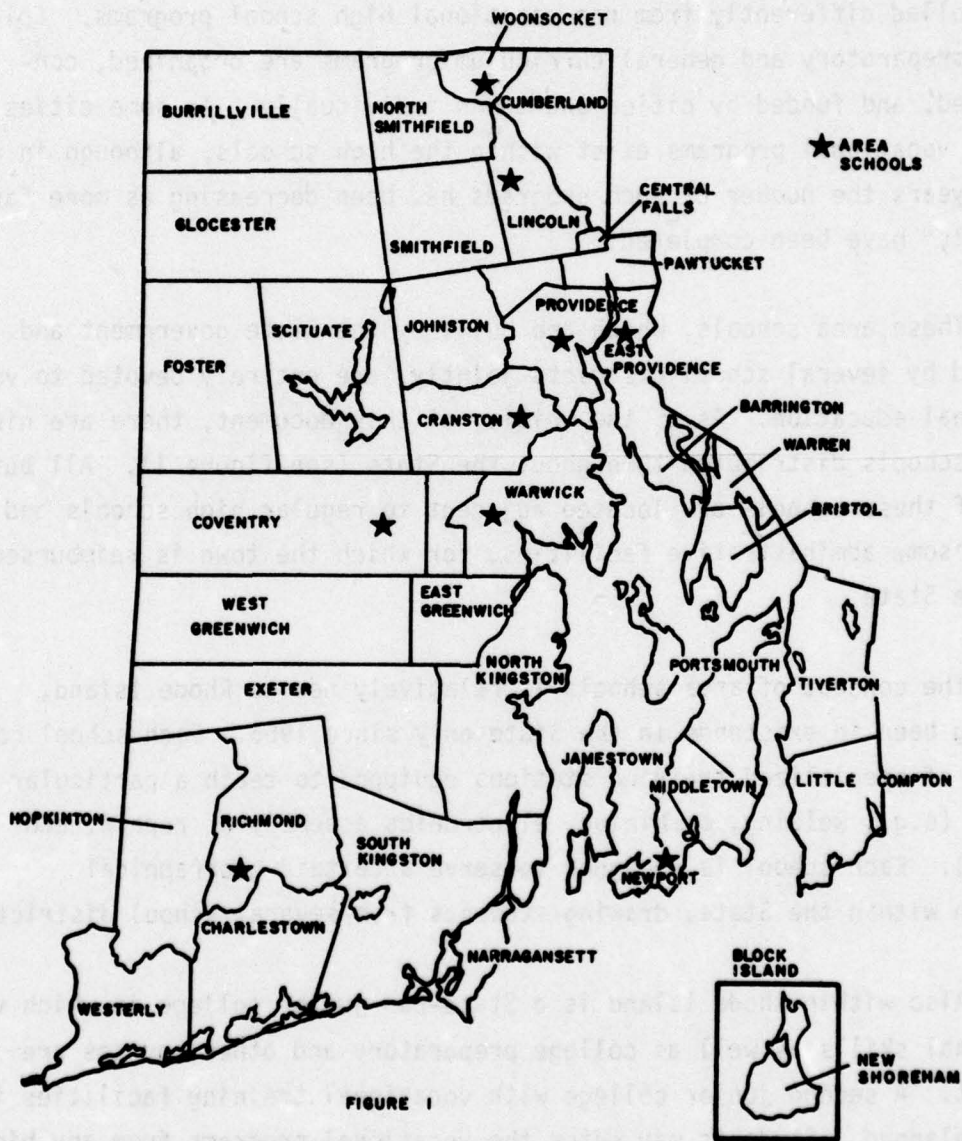


FIGURE 1

CHAPTER 3

DYNAMIC MODELING

To make a successful model of a complex entity such as the State's educational system, it is necessary to use a modeling scheme that can handle two very different types of phenomena: the physical changes that occur naturally (such as aging, depreciation, and so on); and human decisions. There are numerous modeling techniques in which these two concepts are not separated, but instead are lumped together as trends; that is, as directions and rates of change of some quantity (such as the population or the school budget). This latter type of modeling is usually based on linear extrapolations or some other type of curve-fitting method, and is valuable for short-term projections of two to four years. To assess long-term consequences or the effects of any changes in policy, external conditions, social preferences, or any other changes, it is necessary to analyze the system, that is break it down into its component parts and then model these components individually.

This process, referred to variously as dynamic modeling, system dynamics, or behavioral modeling, involves two stages: the definition of the concepts and terms to be included in the model as well as their interrelationships, and the quantification of all items. The first stage is the most crucial; in it, the structure of the system is obtained and described in some fashion, usually as a flow chart such as those appearing in the next chapters. In this stage the purpose and use of the model must be recognized so that important elements for consideration can be included, and ones that have no impact on the goals of the modeler or model user can be omitted.

The second stage also requires some boldness, since the modeling process requires that all variables be quantified, not merely ones already scientifically measurable, such as population. Numbers relating to likes and dislikes of the people involved in the system must also be found. Furthermore, preferences will change over the time span of the model, and assessments must be made of the direction and magnitude of these changes so they can be incorporated into the model. This change of preferences in response to changes in other factors of the model will often cause a reversal or acceleration of the original change - thus forming what is commonly referred to as a feedback loop. An illustration of this might be taken from population growth in a limited region such as an island. As population increases, causing crowding and shortages of various kinds, more and more couples will opt for smaller families, thus reducing the population growth rate and reducing the rate of crowding and shortages.

Thus, the key to dynamic modeling is the identification and quantification of the elements of the system being modeled. The elements included in the model, which we call the components, are the basic building blocks of the model. These can be arranged in clusters of related factors, or directly into large groupings describing one particular functional area of the system. These larger functional areas, or sectors, are pieces of the model felt to be logically separate from other pieces, or at least conventionally thought of as distinct. For example, a model of a city would have a population sector separate from an industrial growth or transportation sector, or from any other sectors pertinent to the goal of the model.

However, no sector is completely independent of the rest of the model, and the connections between sectors, or interfaces, often cause problems out of proportion to their complexity. In the model presented here, each sector is constructed and tested separately with the

interfaces replaced by non-reactive components. When two or more sectors are interconnected, new feedback loops are formed in places where none previously existed. Often this causes grave model problems (such as oscillations or wild growth) which, although a nuisance, point out a defect in one of the sectors.

COMPILER

In exercising the Rhode Island Model a flow-chart-oriented compiler, called SMT, was used rather than an equation-oriented compiler such as the older DYNAMO programming language which was first used for dynamic modeling.* SMT has the same output characteristics as other compilers, but has two advantages in that it is self-checking for numerical inaccuracies, and it has more options for model testing.

SMT models continuous systems rather than discrete events as do some other compilers, with an advantage in smaller run costs. One disadvantage of SMT is that fractional values are given for numbers of students in various places within the model. These values can be regarded as averaged estimates, however, rather than as actual numbers.

Another approximation is made in this model regarding school year. Students are considered to flow continuously, year-round, from grade to grade and from school to vocation, rather than only in June of each year. Again, this drastically cuts computer costs at only a slight loss in realism. To determine the number of graduates in any June, we merely take the annual rate of graduation effective at that time in the model. Values for any other quantity can be determined similarly.

* A complete description of SMT is available from S. Erickson as an unpublished manuscript.

NOTATION USED

In the sections that follow, a standardized, almost algebraic, notation is used to describe the model components and their interconnections. A block representing population, which might be called POP in the listings, is shown to be a function of three rates: birth rate (BR), death rate (DR), and migration rate (MIGR) by the following formula:

$$POP = \int_{t_0}^t (BR - DR + MIGR) dt + POP_0$$

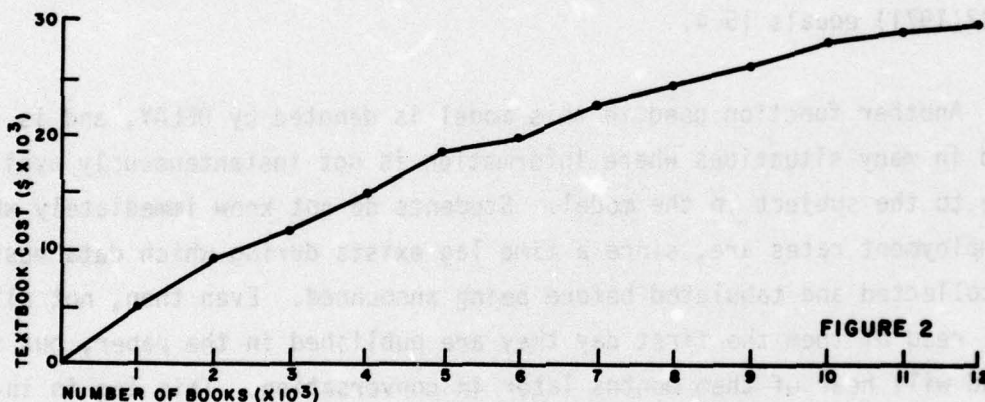
The population POP is, in mathematical terms, an integration of three rates, and in flow chart terminology, it is an integrator block with three inputs: BR, DR taken negative, and MIGR. This merely means that the amount of births plus immigration less deaths in Rhode Island each year is added to the existing population to find the population one year later. In actuality, periods much smaller than one year are used for more accurate calculations. POP_0 in the above equation is the initial population at the start of the model run, in the year t_0 .

Besides integrator blocks, the Rhode Island Model uses multiplication (indicated in the equations by a dot), summation, division, the minimum or maximum of two variables, as well as tabular functions.

A tabular function is merely a numerical relation between two elements. For example, if textbook cost per student is a function of the number of students, it should decline for larger numbers of students owing to a lowered printing costs. If data on printing costs were obtained according to the following hypothetical table:

NUMBER OF BOOKS	COST PER BOOK (\$)
0 - 1000	5
1001 - 2000	4
2001 - 5000	3
5001 - 10,000	2
10,001 and up	1

then the 1000th book would cost \$5.00 but the next one only \$4.00, and so on. This information could be displayed as in figure 2, which is the display method used in the following chapter.



In the text these functions are also given as tables, in the form

$$TBC = f(NSTU); 0, 12,000; 0/5000/9000/12,000/15,000/18,000/20,000/22,000/24,000/26,000/28,000/29,000/30,000$$

where TBC is the total textbook cost in dollars and NSTU is the number of students. The first two numbers in this format are the lower and upper end of range of the independent variable, NSTU; the remaining numbers are values of TBC for equally spaced values of NSTU. Between these points the function is linearly interpolated.

One frequent use of this form of function is the insertion of actual or smoothed data for a number of years. In this usage, the independent variable would be years, the dependent would have the annual values of whatever quantity was being input. As an example, class size from statistical records might be

$$\text{CLSIZ} = f(\text{TIME}); 1960, 1970; 16.1/16.2/16.4/16.7/15.9/16.3/16.6/15.2/15.1/15.4/15.4.$$

The question arises as to what values are taken by the function after the last date listed. For all SMT functions, the value used is the upper value on the table; thus, in the above example, $\text{CLSIZ}(1971)$ equals 15.4.

Another function used in this model is denoted by DELAY, and is used in many situations where information is not instantaneously available to the subject in the model. Students do not know immediately what unemployment rates are, since a time lag exists during which data must be collected and tabulated before being announced. Even then, not all will read of them the first day they are published in the paper, but instead will hear of them months later in conversation. This lag in information is modeled by an average delay time in the notation

$$\text{PUR} = \text{DELAY}(\text{UR}, 1)$$

where UR is the unemployment rate, PUR is the perceived unemployment rate, and 1 represents a one-year average time lag in information. This delay element can also be used to model the flow of students from one year to the next. For example, the number of students in the twelfth grade is given by the number in the eleventh grade the previous year less the fraction of students who drop out

$$\text{STU12} = \text{DELAY}(\text{STU11}, 1) \cdot (1 - \text{DROPF}).$$

In SMT terminology, this is written as

$$STU12 = STU11(t-1) \cdot (1-DROPF).$$

In this case, the design of the flow is made even clearer by not using the DELAY notation.

CHAPTER 4

RELEVANT PREVIOUS WORK

There have been a number of regional models already constructed using dynamic modeling, but none specifically deals with labor force composition and training as this Rhode Island Model does. Rather, they have been focused on two extremely important aspects of state or regional planning: land use and economic change.

One of the earliest, and yet most extensive, regional simulation efforts was the Bay Area Simulation Study, BASS, which had the nine counties around San Francisco Bay as its domain.² This study passed through three phases during its six-year span, with the first being devoted to household locations and the factors that determined them, the second involving effects of transportation on land use, and the third dealing with industrial effects on land use. It was differentiated into 22 industrial types, each extrapolated to grow at rates particular both to the industrial type and the prior growth of the Bay Area. This method of extrapolation, however, has since been severely criticized as producing poorer agreement with actual growth than the direct use of national growth rates.³ BASS, however, was a monumental achievement in data handling and organization, whatever the extent of its methodological shortcomings.

The second major regional modeling effort was done by the Battelle Memorial Institute, Columbus, Ohio, for the Susquehanna River Basin.¹ In this model, the defining quantity was water use, rather than land. Again, an industry-type partitioning was performed, and growth was based on the export base theory. This hypothesis determines the economic growth of exporting industries in terms of their externally

projected export markets, and of other industries in terms of what the export sector requires.

Several cities have been the subjects of economic growth modeling; notably, St Louis⁴ and Philadelphia.⁵ The former study emphasized the demographic sectors as the key element determining growth or the economic health of the city, while the latter applied econometric theory to a small, open region. Both of these projects took into account the skill levels in the labor market, but neither attempted to analyze the effects of different training rates.

CHAPTER 5

MODEL ASSUMPTIONS AND EQUATIONS

The prototype Rhode Island Model was written principally to describe the operation of the vocational education component of the Rhode Island Department of Education. As such, it explicitly treats two areas of concern to the Department: the enrollment in the vocational education program, both now and in the future, and the costs involved.

As with most dynamic models, the Rhode Island Model is divided into several interconnected sectors, each simulating a specific topic. Figure 3 shows a sectorial view of the model. Involved with the question of enrollment are two sectors: the student population sector, and the student attractiveness sector which calculates the number of students who are sufficiently attracted to vocational education to enroll in a program. Furthermore, a third sector, called school budget, describes the costs of these programs. In addition to modeling the students and their preferences, the model relates the impact of their choices on the labor market, and indeed on Rhode Island as a whole, both in industrial development and in unemployment and welfare expenses. This latter category is included in the State budget block, which excludes the school budget portion of State expenses. Internally, the labor market is divided into two subsectors, one treating the unskilled working population, and a second treating the skilled population. In the model, professional occupations do not play a role.

Between these two labor market sectors is situated the manpower training sector, which encompasses all programs that train the unskilled for skilled jobs or retrain skilled workers into new occupations with improved job prospects.

A second block models the role of the military training sector, which details the benefits to the State of returning veterans, who possess usable skills. Also connected to the labor market is the industrial development sector, which describes economic growth in terms of job openings both in skilled and unskilled professions.

In the following text each sector is described separately by its purposes, a list of the variables used, and a description of each component included in the sector. One or more illustrative runs of each sector are also provided.

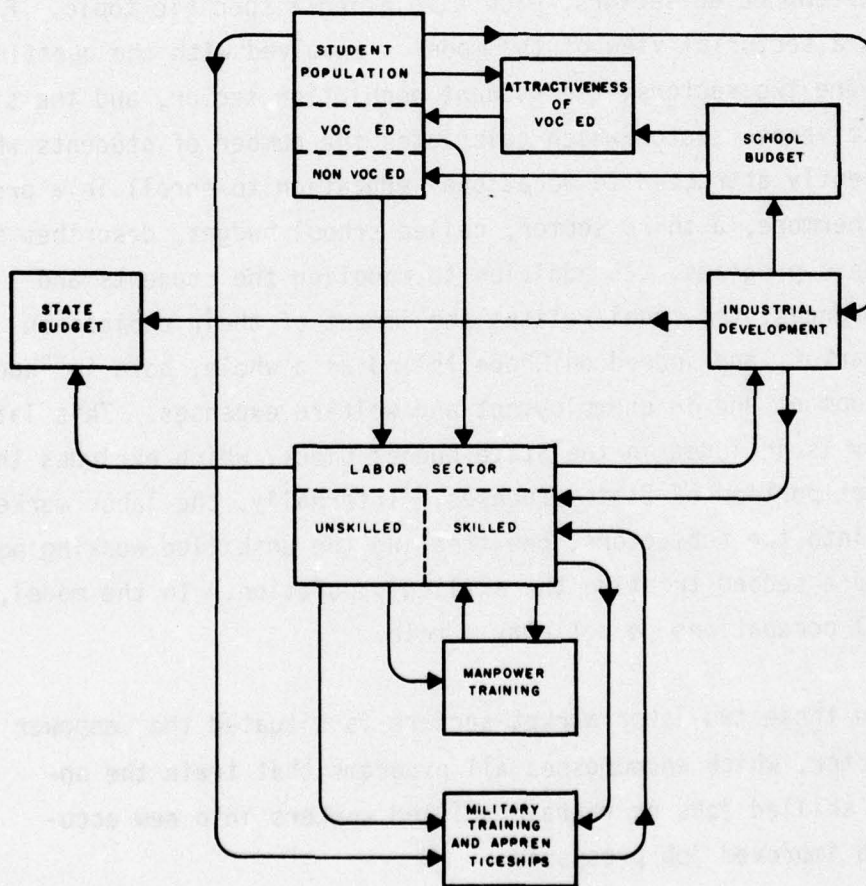


FIGURE 3

THE STUDENT POPULATION SECTOR

The Student Population Sector is designed to monitor the flow of students through the area schools and local high schools and through the vocational programs of the State junior college. As shown in figure 4, the source of all upper-grade high school students is the ninth grade population, which feeds into the four main high school programs: college preparatory, general curriculum, and the local and area vocational programs.

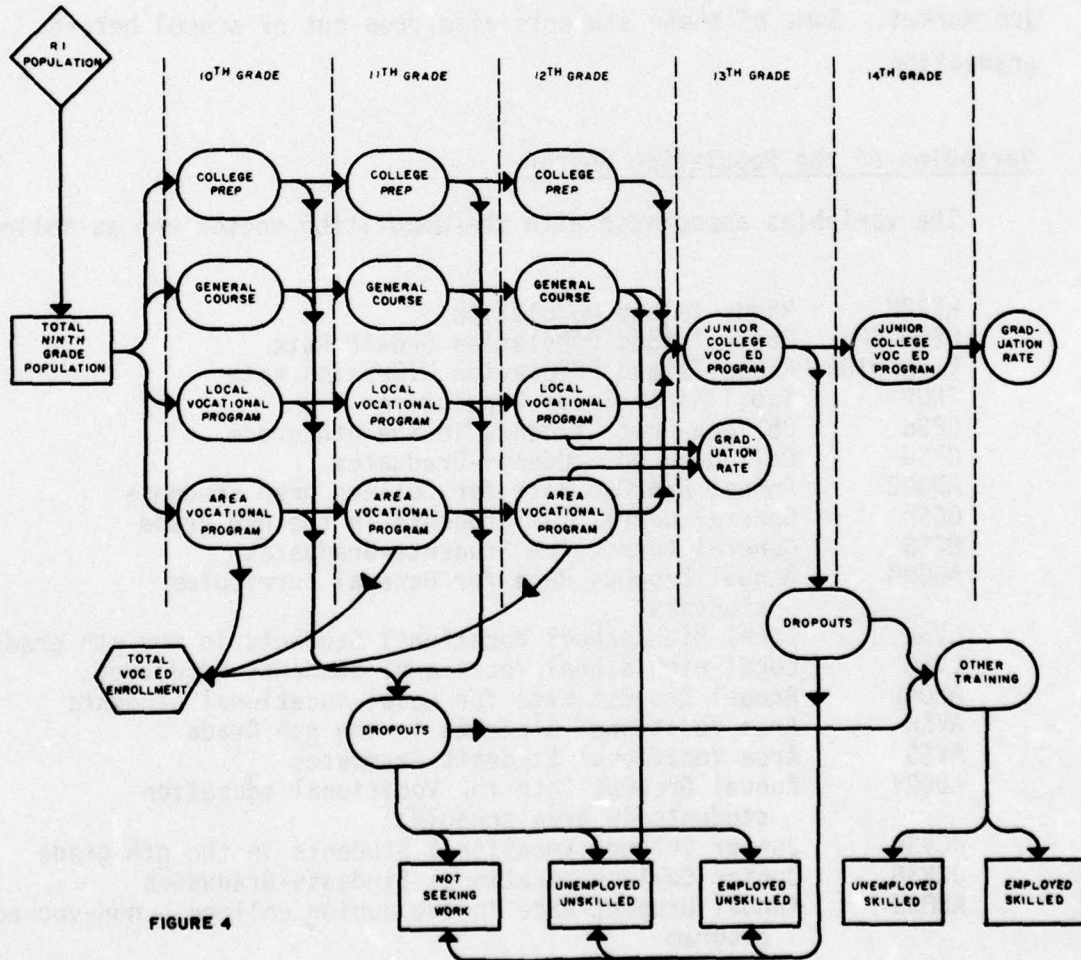


FIGURE 4

Some students from each of the grades drop out of school; the remainder go on to graduate. Some of the college preparatory school graduates enter a junior college vocational educational program; the remainder enter other programs not included in the model. General curriculum graduates also can enter the vocational education junior college programs, enter the job market as unskilled graduates, or leave the system by not seeking work. Similarly, vocational education high school graduates can continue their vocational training in junior college or enter the labor market as skilled graduates. Likewise, graduates from junior college, after completing a one- or two-year program, enter the job market. Some of these students also drop out of school before graduation.

Variables of the Population Sector

The variables associated with the population sector are as follows:

RIPOP	Rhode Island POPulation
RIPOPGR	Rhode Island POPulation Growth Rate
RIPOPMIGR	Rhode Island POPulation MIGration Rate
TNGP	Total Ninth Grade Population
CPSn	College Prep Students in the <u>n</u> th grade
CPSG	College Prep Students-Graduates
ADORC	Annual DropOut Rate for College prep students
GCSn	General Curriculum Students in the <u>n</u> th grade
GCSG	General Curriculum Students-Graduates
ADORG	Annual DropOut Rate for General curriculum students
LVSn	Local high school Vocational Students in the <u>n</u> th grade
LVSG	Local high school Vocational Students-Graduates
ADORL	Annual DropOut Rate for Local vocational students
AVSn	Area Vocational Students in the <u>n</u> th Grade
AVSG	Area Vocational Students-Graduates
ADORV	Annual DropOut Rate for Vocational education students in area schools
JCVSn	Junior College Vocational Students in the <u>n</u> th grade
JCVSG	Junior College Vocational Students-Graduates
ADORJ	Annual DropOut Rate in the Junior college - non-voc ed program

TVEEA	Total Vocational Education student Enrollment - Area schools
TVEEP	Total Vocational Education student Enrollment - Post-secondary schools
TADH	Total Annual Dropout rate - High school
TADP	Total Annual Dropout rate - Post-secondary schools
PLE	Placement Effectiveness
GRR	GRaduation Rate - area schools and junior college
JCTYPF	Junior College Two Year Program Fraction

Rhode Island Population, RIPOP. RIPOP measures the total number of people residing in Rhode Island. Each year the population is increased from two sources: the excess of births over deaths and the excess of immigration from outside Rhode Island over the emigration. The value of RIPOP in 1960 is taken to be 853,400. The rate equation and tabular function defining RIPOP are

$$d(\text{RIPOP})/dt = \text{RIPOPGR} \cdot \text{RIPOP} + \text{RIPOPMIGR}$$

$$\text{RIPOPGR} = f(t); 1961, 1980; .010776/.010515/.010164/.009637/$$

$$.008914/.008155/.007552/.007208/$$

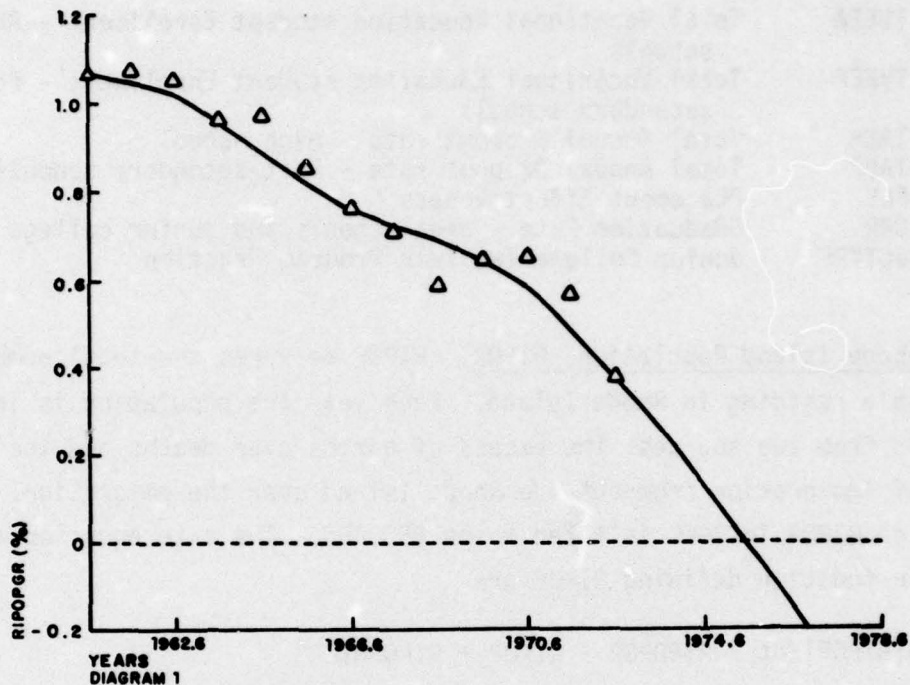
$$.006947/.006547/.005851/.004902/$$

$$.003783/.002562/.001280/-.00003/$$

$$-.00135/-.00266/-.00398/-.00529$$

RIPOPGR, the difference between births and deaths only, is taken from available statistical data.⁶ A spline fit was made to the data from 1960 through 1973, and extrapolated to 1980. The raw census data are shown as small triangles in diagram 1.*

* Graphic representations of the inputs to the model are referred to in this document as diagrams; graphic representations of the model outputs and other, non-input illustrations are referred to as figures.



Rhode Island Migration Rate, RIPOPMIGR. The net migration into Rhode Island is a result of many factors, including the excellent climate and location, the proximity to other desirable areas, and so on. For the purposes of this model, only the economic motivations for relocation, as discussed in the Labor Sector, are examined. RIPOPMIGR is determined by the equation

$$RIPOPMIGR = APUW \cdot MUW + APUL \cdot MUL + APSW \cdot MSW + APSL \cdot MSL^*$$

APUW, APUL, APSW, APSL are taken to be the average family size of unskilled employed workers, unskilled unemployed workers, skilled employed workers and skilled unemployed workers, respectively. Their

*MUL, MSW, MUW, and MSL are defined in the Labor Sector as migration rates of the four groups.

values are determined as follows from a least squares fit to Rhode Island migration estimates derived by approximating migration curves.

$$\text{APUW} = 4.739$$

$$\text{APUL} = 3.658$$

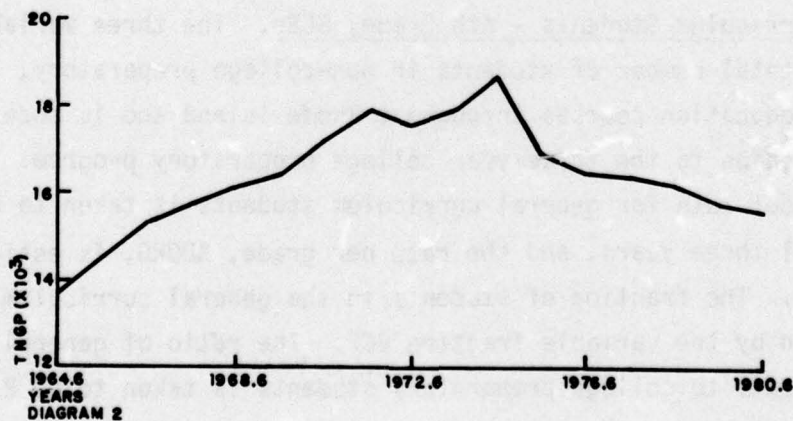
$$\text{APSW} = 2.438$$

$$\text{APSL} = 4.490$$

Total Ninth Grade Population, TNGP. The total number of ninth grade students in all the schools in Rhode Island is measured by TNGP. The enrollment for the ninth grade is assumed to be the enrollment for lower grades as the students move through the school systems. The data used in the model are taken from Statistical Tables 1965-1973 of the Department of Education,⁷ as shown in diagram 2.

$$\text{TNGP} = \text{TNGP}(t)$$

$$\text{TNGP} = f(t); 1965, 1981; 13684/14517/15345/15696/16144/16426/17248/17905/17614/17946/18738/16905/16504/16398/16164/15775/15569$$



College Preparatory Students - nth Grade, CPSn. The three variables CPSn count the total number of students enrolled in the nth grade through all the schools in the State in college preparatory programs. The fraction of students in the college preparatory program is given by the variable fraction, CPF. The annual dropout rate from the ninth grade, ADON, was calculated from 1971-1972 enrollment figures. The variables AVF and LVF refer to the fraction of ninth grade graduates who enter area and local vocational schools, respectively. The number of graduates from this program, CPSG, is given as the number of students entering twelfth grade, CPS12, times the fraction of students not dropping out, 1-ADORC. The annual dropout rate for college preparatory students is taken to be the same for all three years, and the rate per grade, ADORC, is estimated to be .03. The ratio of college preparatory students to general curriculum students is taken as 3:2 for the entire range of the model.

$$\begin{aligned}
 \text{CPS10} &= \text{CPF} \cdot \text{TNGP}(t-1) & \text{ADORC} &= .03 \\
 \text{CPS11} &= (1-\text{ADORC}) \cdot \text{CPS10}(t-1) & \text{ADON} &= .052 \\
 \text{CPS12} &= (1-\text{ADORC}) \cdot \text{CPS11}(t-1) \\
 \text{CPSG} &= (1-\text{ADORC}) \cdot \text{CPS12}(t-1) \\
 \text{CPF} &= .60 (1-\text{AVF}-\text{LVF}) \cdot (1-\text{ADON})
 \end{aligned}$$

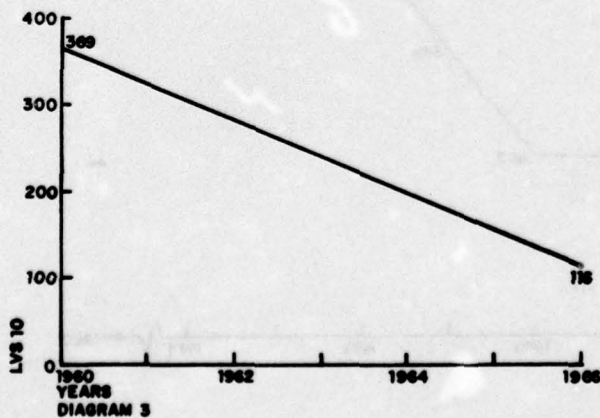
General Curriculum Students - nth Grade, GCSn. The three variables GCSn count the total number of students in non-college preparatory, non-vocational education courses throughout Rhode Island and is modeled in a similar fashion to the three-year college preparatory program. The annual dropout rate for general curriculum students is taken to be the same for all three years, and the rate per grade, ADORG, is estimated to be .20. The fraction of students in the general curriculum program is given by the variable fraction GCF. The ratio of general curriculum students to college preparatory students is taken to be 2:3.

$$\begin{aligned}
 \text{GSC10} &= \text{GCF} \cdot \text{TNGP}(t-1) \\
 \text{GCS11} &= (1-\text{ADORG}) \cdot \text{GCS10}(t-1)
 \end{aligned}$$

$$\begin{aligned} \text{GCS12} &= (1-\text{ADORG}) \cdot \text{GCS11}(t-1) \\ \text{GCSG} &= (1-\text{ADORG}) \cdot \text{GCS12}(t-1) \\ \text{GCF} &= .40 (1-\text{AVF}-\text{LVF}) \cdot (1-\text{ADON}) \\ \text{ADORG} &= .20 \\ \text{ADON} &= .052 \end{aligned}$$

Local Vocational Students - nth Grade, LVS_n. The three variables LVS_n count the students enrolled in the nth grade vocational programs in all the local high schools in Rhode Island. LVF, the fraction of students attending local vocational schools, decreases from 1965 through 1975 upon completion of additional area schools. The variable LVS10 reflects this decrease as can be seen in diagram 3. As above, LVSG indicated the number of students graduating annually from this course of study. The annual dropout rate from the local schools, ADORL, is estimated to be .10.

$$\begin{aligned} \text{LVS10} &= \text{VDFG}(t) \\ \text{LVS11} &= (1-\text{ADORL}) \cdot \text{LVS10}(t-1) \\ \text{LVS12} &= (1-\text{ADORL}) \cdot \text{LVS11}(t-1) \\ \text{LVSG} &= (1-\text{ADORL}) \cdot \text{LVS12}(t-1) \\ \text{LVF} &= \text{LVS10}/\text{TNGP}(t-1) \\ \text{ADORL} &= .10 \\ \text{LVS10} &= f(t); 1960, 1966; 369/116 \end{aligned}$$



Area Vocational Students - nth Grade, AVSn. The three variables AVSn count the students in the nth grade of the area vocational schools in Rhode Island. The fraction of ninth-grade students entering the area schools, AVF, is limited (assuming no excessive crowding) by the designed capacity of the schools, DCAPA, and by the ratio of students willing to apply, OAA. The annual dropout rate from the area schools, ADORV, is estimated to be .05.

$$AVS10 = \text{Min} \{OAA \cdot TNGP(T-1), 1.10 \text{ DCAPA}\}$$

$$AVS12 = (1-ADORV) \cdot AVS11(t-1)$$

$$AVSG = (1-ADORV) \cdot AVS12(t-1)$$

$$ADORV = .05$$

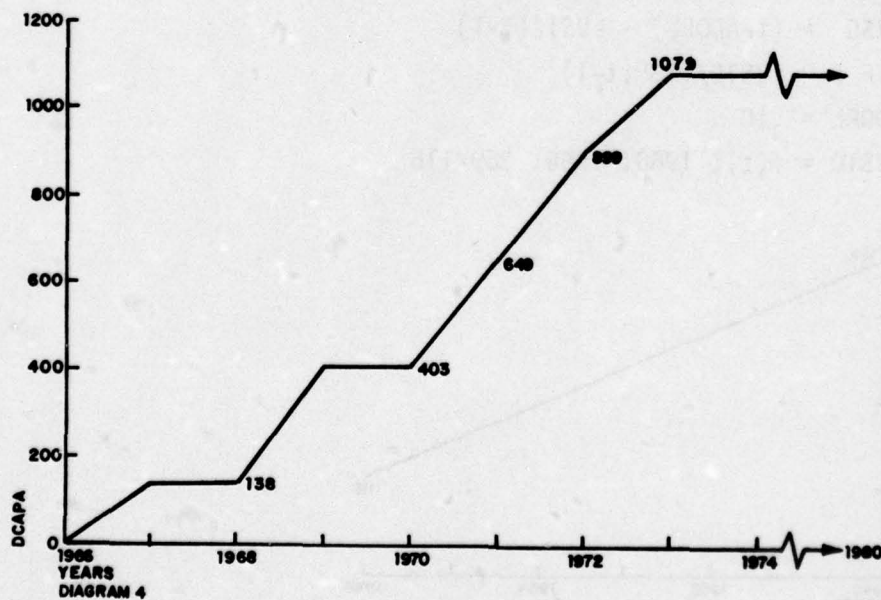
$$AVF = AVS10/TNGP(t-1)$$

$$DCAPA = DCAPA(t)$$

$$DCAPA = f(t); 1966, 1979; 0.0/138/138/403/403/649/899/1079$$

$$1079/1079/1079/1079/1079/1079$$

Diagram 4 shows the designed capacities for all area schools combined by year.



Junior College Vocational Students - nth grade, JCVSn. The two variables JCVSn count the students in the nth grade of RIJC; i.e., in the freshman or sophomore year. The thirteenth year enrollment is limited by the school capacity, assuming two and one-half students per training station, and by the number of graduates from the high school courses who desire to attend. The four fractions JCVFC, JCVFG, JCVFL, and JCVFV measure the proportion of students from each graduating group who go on to enter the State junior college vocational program. These values are scaled so that approximately 1.5 percent enter from college preparatory programs, 2 percent enter from general curriculum programs, 31.5 percent from the local vocational schools, and 65 percent enter from the area schools. They are scaled so that they also agree with 1972 State enrollment figures.

$$\text{JCVS13} = \text{Min} \{ \text{CPSG} \cdot \text{JCVFC} + \text{GCSG} \cdot \text{JCVFG} + \text{LVSG} \cdot \text{JCVFL} + \text{AVSG} \cdot \text{JCVFV}; 1.8528 \cdot \text{DCAPP} \}$$

$$\text{JCVSG} = \text{JCVS14}(t-1) \cdot (1-\text{ADORJ3}) + \text{JCVS13}(t-1) \cdot (1-\text{ADORJ1}) \cdot (1-\text{JCTYPF})$$

$$\text{JCVS14} = (1-\text{ADORJ2}) \cdot \text{JCVS13}(t-1) \cdot \text{JCTYPF}$$

$$\text{JCVFC} = .3377 \cdot \text{OAP}$$

$$\text{JCVFG} = .4414 \cdot \text{OAP}$$

$$\text{JCVFL} = 7.08 \cdot \text{OAP}$$

$$\text{JCVFV} = 14.66 \cdot \text{OAP}$$

$$\text{JCTYPF} = .6093$$

$$\text{ADORJ1} = .10$$

$$\text{ADORJ2} = .26$$

$$\text{ADORJ3} = .10$$

JCTYPF measures the fraction of those students who enter a two-year program; the remaining fraction (1-JCTYPF) complete their Voc Ed

program in one year, assuming they do not drop out of school. The value of JCTYPF used in the model is based upon 1973-1974 RIJC enrollment figures.⁸ ADORJ1, ADORJ2, ADORJ3 measure the dropout rates from the one-year program, from the two-year program the first year, and from the two-year program the second year, respectively.

Total Vocational Education Student Enrollment - Area Vocational Schools, TVEEA. The total number of students enrolled in the area vocational schools is merely the sum of the 10th, 11th, and 12th grade enrollments. This figure relates to the overall cost of running the schools.

$$TVEEA = AVS10 + AVS11 + AVS12$$

Total Vocational Education Student Enrollment - Post-Secondary Schools, TVEEP. The total number of students enrolled in the junior college vocational programs is the sum of those in the two grades.

$$TVEEP = JCVS13 + JCVS14$$

Total Annual Dropout Rate - High School, TADH. The total number of students leaving high school before graduation is modeled in a coordinated manner with the enrollment variables. In the model, students leave at a constant percentage rate, proportional to the number of students in each grade.

$$TADH = ADORC \cdot (CPS10+CPS11+CPS12) + ADORG \cdot (GCS10+GCS11+GCS12) \\ + ADORL \cdot (LVS10+LVS11+LVS12) + ADORV \cdot (AVS10+AVS11+AVS12)$$

Total Annual Dropout Rate - Vocational Programs in Post-Secondary Schools, TADP. The total number of Voc Ed students leaving junior college before completion of a program is measured by TADP.

$$TADP = ADORJ1 \cdot (1 - JCTYPF) \cdot JCVS13 + ADORJ2 \cdot JCTYPF \cdot JCVS13 + ADORJ3 \cdot JCVS14$$

Unemployed Unskilled Youth Entering the Labor Market, UHS. Three sources send youth to the unskilled labor pool: graduates from the general curriculum program who do not continue their training in the junior college, dropouts from high school, and dropouts from the junior college (both Voc Ed students in the junior college (TADP) and general curriculum students (TADG)). Each of these groups is assumed to be seeking employment. The fraction of graduates or dropouts who do not seek work is represented by HNSW. ADORP is the post-secondary school annual dropout rate.

$$UHS = GCSG \cdot (1 - JCVFG - HNSW) + (TADH + TADJ + TADJG) \cdot (1 - HNSW)$$

$$TADJG = ADORP \cdot TVEEP$$

$$JCVFG = .0221$$

$$HNSW = .16$$

$$ADORP = .10$$

Graduation Rate, GRR. The number of trained graduates from the area schools and the junior college is modeled as the number who successfully complete the required program of study.

$$GRR = AVSG + JCVSG$$

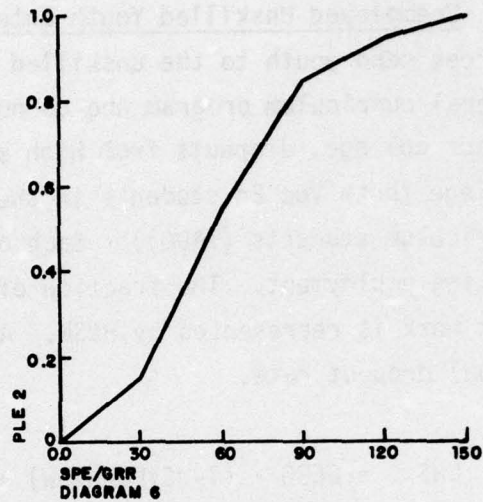
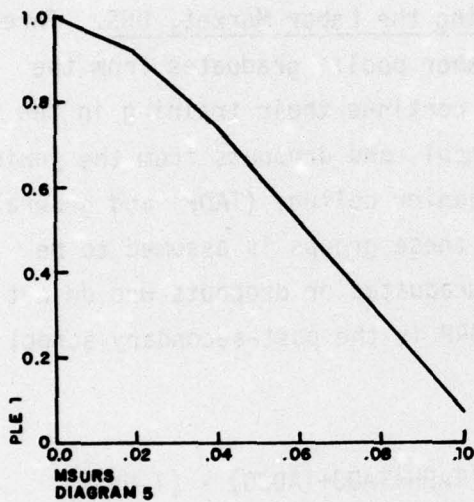
Placement Effectiveness, PLE. The fraction of students placed in skilled jobs upon graduation is related to two factors: the State unemployment rate and the amount of money spent per student on placement by the State, SPE. The measured State unemployment rate for skilled labor is MSURS.

$$PLE = PLE1 (MSURS) \cdot PLE2 (SPE/GRR)$$

$$PLE1 = f_1(MSURS); 0.0, 0.1; 1.0/.92/.75/.52/.30/.08$$

$$PLE2 = f_2(SPE/GRR) 0.0, 150; 0.0/.15/.55/.85/.95/1.0$$

Diagrams 5 and 6 show the relationship of these factors to placement effectiveness.



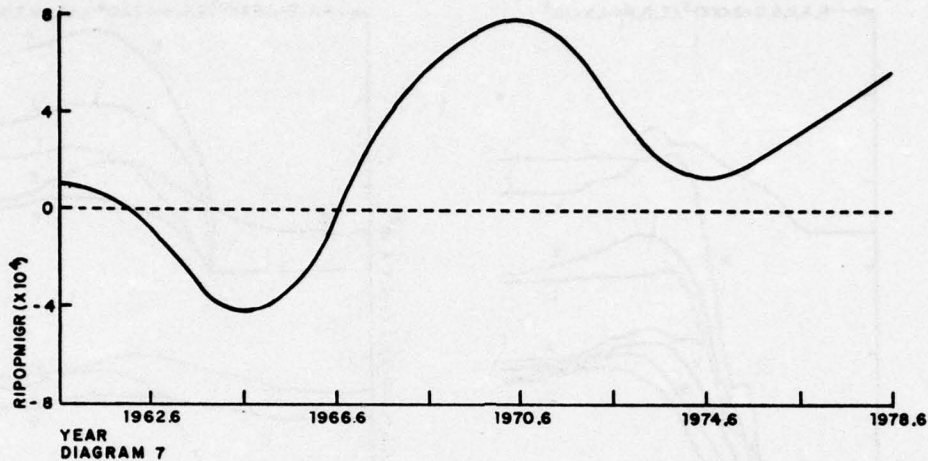
Population Sector Runs

In order to investigate and illustrate the behavior of this sector alone, it is necessary to isolate it from the other sectors of the model. The population sector is largely autonomous, accepting inputs only in the migration term, RIPOPMIGR, and attractiveness factors for the tenth grade area school and thirteenth year junior college enrollments, OAA and OAP. For the independent sector runs, RIPOPMIGR is replaced by a function of time chosen to cause the population to just fit census data:

$$\text{RIPOPMIGR} = \text{RIPOPMIGR}(t)$$

$$\text{RIPOPMIGR} = f(t); 1961, 1980; 989/592/-742/-2925/-4252/-3203/ \\ 31/3621/6009/7408/7755/6801/4478/ \\ 2194/1368/1961/3253/4550/5851/7159$$

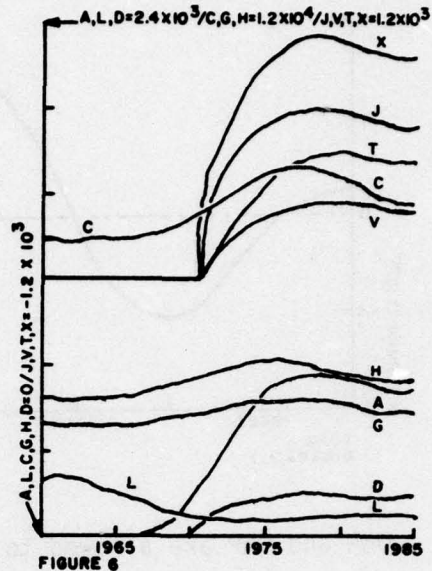
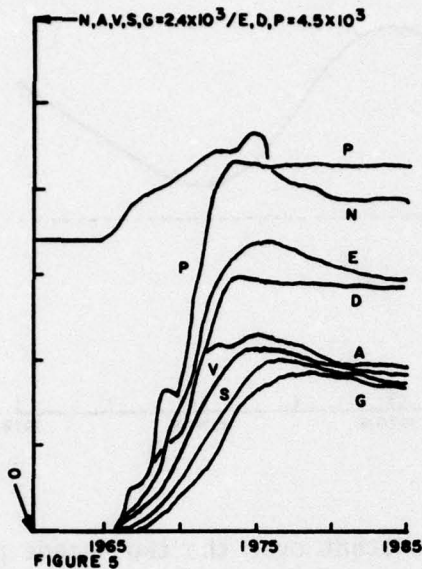
This migration function is graphically depicted in diagram 7.



OAA and OAP are allowed to be constant over the two-decade period under consideration, and are set equal to .05. With these assumptions inserted into the population sector, a standardized run of this sector alone may be obtained without any concern for the behavior of the remainder of the model. In essence, we have cut the ties interfacing this group of components with the rest.

Figures 5 and 6 illustrate the trends of the more basic variables of this sector. In figure 5, the upper curve, N, denotes the total ninth grade population in Rhode Island, while the lower set of curves show the student response to the area school building programs. Curves D and P indicate the number of students needed to fill the area schools to capacity at the two- and three-shift-per-station level, respectively. The actual enrollment in area schools is shown by curve E, which runs between these two former curves for most years.

A breakdown of the students' progression through the three-year programs and on to graduation appears below the capacity curves. Curve A shows the tenth grade population, rising almost in synchrony with the building completions. Lagging behind this, in a succession,



are the eleventh grade enrollment, V, the twelfth grade enrollment, S, and finally the graduates, G. Each of these is slightly lower than its predecessor because a fraction of students drop out of each year's program.

Figure 6 shows a more comprehensive view of the vocational school program. Graduates from the four tracks for high school students are plotted: the area schools are represented by curve A; the local vocational schools by L; general curriculum students by G; and college preparatory students by C. A gradual increase in the latter two occurs because of the population rise. However, due to the closing of several facilities, the local vocational enrollment drops. As noted in figure 5 the area school enrollment, E, shows a large rise with the new building completions. The number of area school students, however, is not sufficient to reduce the general curriculum and college preparatory students at any time in the interval of study; instead the area schools absorb most of the population rise.

Figure 6 also shows the variation in junior college enrollment in vocational programs. The first-year population is denoted by curve J on the figure; some of these students graduate after completing a one-year program, others drop out, leaving the remainder in the second-year programs are combined in the curve with label T. The curves H and D are respective high school and junior college dropout rates.

Finally, total enrollment in area schools, shown by curve E in figure 5, and in vocational programs of Rhode Island Junior College, shown by curve X in figure 6, constitute the basis for computing the required budget expenses by the Department of Education for vocational education. Of course, the values obtained in the model run of this sector alone are only the simplest approximations to a projection of student enrollments. Only population growth and school construction have been considered; items such as all psychological variables and the influence of other training programs are neglected. This shows the power of dynamic modeling as a projection and policy tool by allowing many alternative plans and concepts to be tried and by producing better basic enrollment estimates than previously possible.

THE STUDENT ATTRACTIVENESS SECTOR

One of the principal concerns of the Department of Education is the number of students who will enroll in the first year of the area and junior college vocational programs. This initial enrollment is limited by two factors: the capacity of the schools involved and the number of students willing to apply. The first factor is, of course, controlled by the building programs of the State and was discussed in the previous sector. The second, however, raises complicated behavioral questions concerning the facets of life which make Voc Ed attendance attractive or unattractive, as compared to other schools or even no school at all.

In the attractiveness sector we attempt to treat this latter question by ascribing to the State vocational education system a quantity called "overall attractiveness" from which we calculate the number of applicants. As shown in figure 7 this latter variable is made up of four portions, each relating to one cluster of interests of the students. The first, and perhaps most important, is career motivation. Different students will see the career benefits of vocational education differently. Thus, the career attractiveness factor is composed of terms involving starting wages, the skilled vs unskilled wage ratio, the skilled and unskilled unemployment rates, as well as one term concerned with quality of teaching (which, in a mobile environment, may govern the rate at which a young graduate can rise in pay or status).

The second cluster is again a very subjective element - it relates how the students regard the State's opinion of them, such as might be measured by the adequacy of the maintenance given their school or the crowding conditions to which they are subjected.

The third cluster involves the student's self-esteem as affected by his attending a state-run vocational school rather than some other type. The feeling of "belonging," as generated by the school's image in sports or public service, is one feature included; a second is the interest shown by prospective employers in the students before graduation. This might be manifested by co-op programs, union-sponsored job counseling, or employer visits to the school.

The fourth cluster, called nuisance factors, contains four features not included elsewhere. One is the academic prejudice against a non-college course manifested by ninth-grade and earlier-grade teachers and others. Another is peer-group pressure; for example, a student is less likely to go to an area school if very few from his ninth grade class enroll. A further factor is time lost in commuting. And

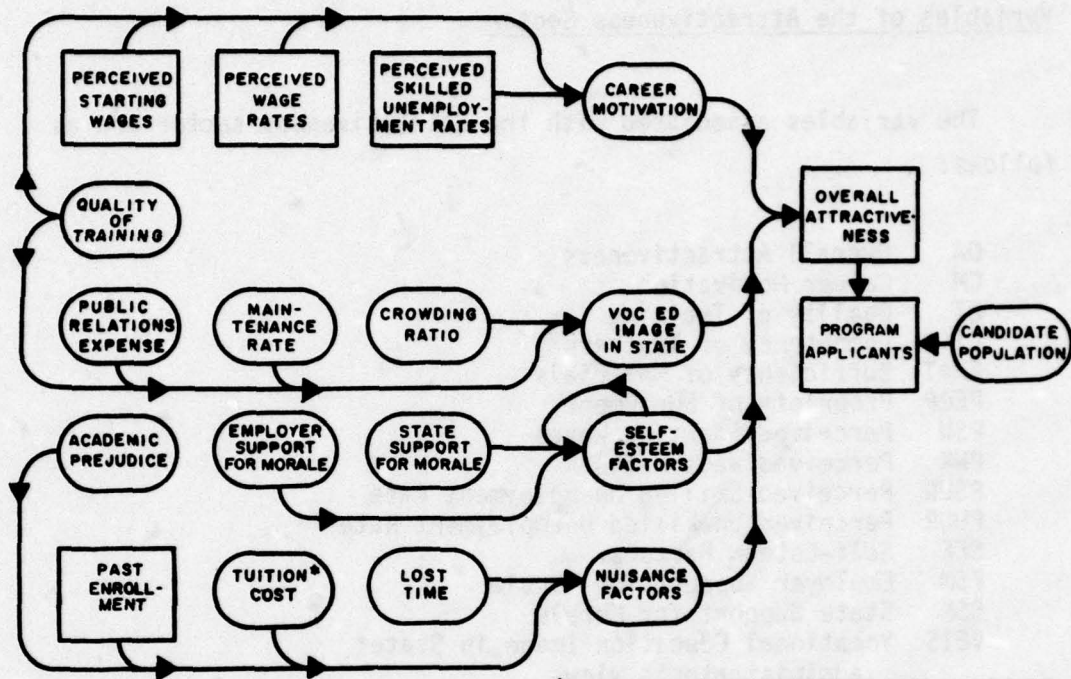


FIGURE 7

* TUITION COST WOULD NOT BE INCLUDED IN THE FLOW CHART FOR AREA SCHOOLS

lastly, tuition sometimes deters enrollment.

In the equations for this sector (which follow), virtually all numbers listed are initial estimates made without a data base. Each of the functions, however, can be determined by sociological techniques, more specifically, via an appropriately designed questionnaire, as is currently planned.

To meet the needs of the Department of Education, which has cognizance over both secondary and post-secondary schools, equations for the attractiveness sector had to be written in two parts, almost identically structured. One subsector, containing variables with suffix A, relates to the area schools; the other, suffixed P, relates to post-secondary schools. Thus, if OA is the overall attractiveness variable, OAA and OAP will be the respective labels for the corresponding variables in the two subsectors.

Variables of the Attractiveness Sector

The variables associated with the attractiveness sector are as follows:

OA	Overall Attractiveness
CM	Career Motivation
QT	Quality of Training
CT	Competency of Teachers
SMAT	Sufficiency of MATerials
PEQP	Propriety of EQuiPment
PSW	Perceived Starting Wages
PWR	Perceived Wage Ratio
PSUR	Perceived Skilled Unemployment Rate
PUUR	Perceived Unskilled Unemployment Rate
SEF	Self-Esteem Factors
ESM	Employer Support for Morale
SSM	State Support for Morale
VEIS	Vocational Education Image in State administrator's view
PRE	Public Relations Expense
MR	Maintenance Rate
CR	Crowding Ratio
NF	Nuisance Factors
AP	Academic Prejudice
PEN	Past ENrollment
LT	Lost Time
TC	Tuition Cost
PA	Program Applicants
LSVS	Locally Supported Voc ed Students

Equations of the Attractiveness Sector

Overall Attractiveness, OA. Overall attractiveness of the Voc Ed system to students is composed of four clusters of factors. It represents the fraction of potential students (ninth graders or high school graduates) who will apply for Voc Ed training.

$$OA = CM \cdot SEF \cdot VEIS \cdot NF$$

Career Motivation, CM. The cluster of variables labeled career motivation sums up the considerations concerning the future of potential Voc Ed trainees. It is intended to take into account the long-term financial and security considerations that play the dominant role in the decision to enter Voc Ed. If the difference in the unemployment rates between the skilled and unskilled labor forces (PSUR-PUUR) is large, the level of career motivation will move as in diagram 8 with CM2 possibly compensating for lower quality training. Similarly the wage ratio, PWR, and the starting wage level, PSW, can compensate for poorer training (diagrams 10 and 11). As the quality of training drops below an acceptable level, a large decline in enrollment will occur according to table CM1 in diagram 9. Lastly, as illustrated in diagram 12, if the unemployment rate for skilled workers, PSUR, is sufficiently large, the students may become too discouraged and pessimistic to make the effort to go through Voc Ed training, even if the unskilled unemployment rate is as high or higher. The constant, SCALF, is used to scale the variable CM to yield the desired value of OA in 1972.

$$CM = SCALF \cdot CM1(QT) \cdot CM2(PSUR-PUUR) \cdot CM3(PWR) \cdot CM4(PSW) \cdot CM5(PSUR)$$

$$SCALFA = .21992$$

$$SCALFP = .06187$$

$$CM1 = f_1(QT); 0.0, 8.0; 0.0/1.0/1.5/1.8/2.0/2.1/2.15/2.2/2.25$$

$$CM2A = f_2\{(PSUR-PUUR)A\}; -.04, .04; 3.0/2.8$$

$$CM2P = f_3\{(PSUR-PUUR)P\}; -.04, .04; 3.0/2.0$$

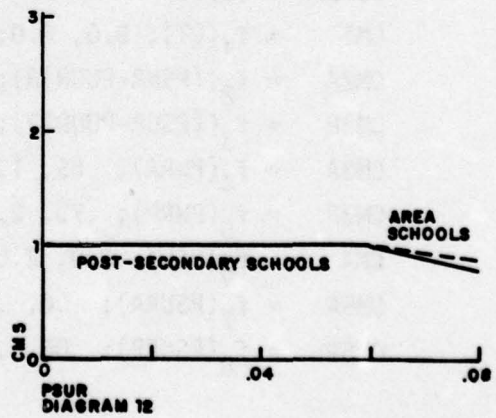
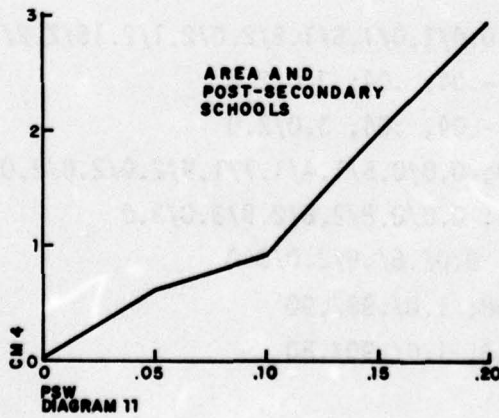
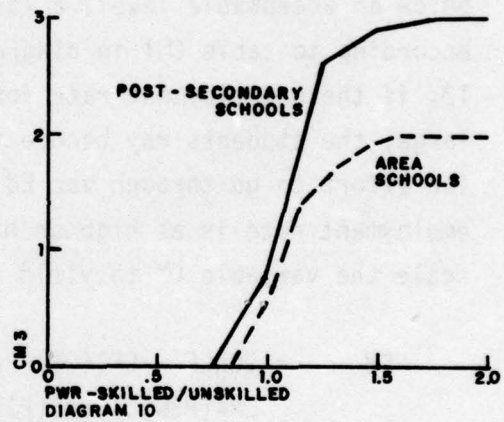
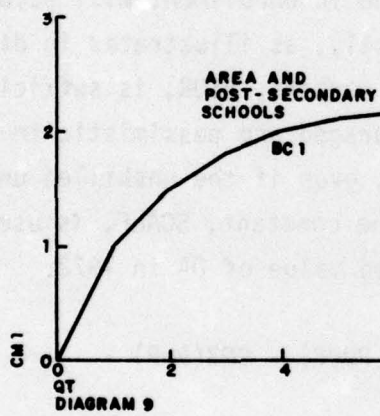
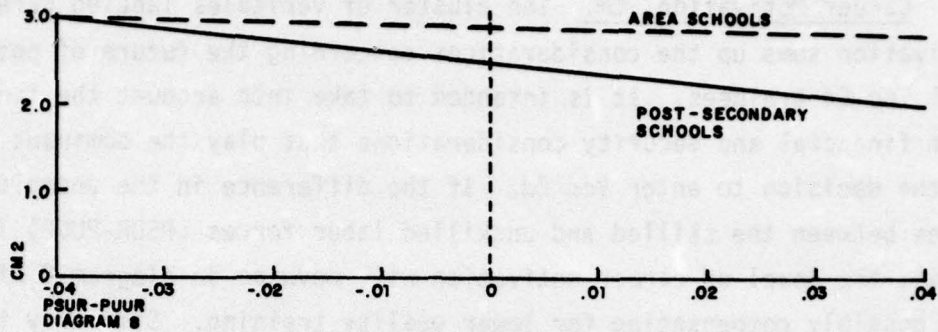
$$CM3A = f_4(PWRA); .85, 1.9; 0.0/0.5/1.4/1.7/1.9/2.0/2.0/2.0$$

$$CM3P = f_5(PWRP); .75, 2.0; 0.0/0.8/2.6/2.9/3.0/3.0$$

$$CM4 = f_6(PSW); 0.0, 2.0; 0.0/.6/.9/2.0/3.0$$

$$CM5A = f_7(PSURA); .06, .08; 1.0/.95/.90$$

$$CM5P = f_8(PSURP); .06, .08; 1.0/.90/.80$$



Quality of Training, QT. The quality of training variable, QT, measures how well, in the eyes of the students, their instruction actually prepares them for successful and gainful employment. QT is one of the four factors in the CM cluster and contains three factors itself. The first depends on the competency of the teaching staff, CT, and reflects how knowledgeable they are, both in the subject matter and also in the methods of successful communication to students. The second factor, SMAT, relates to the sufficiency of materials, since a scarcity in practice items will definitely limit a student's ability to gain experience. The third depends on the propriety of the equipment, PEQP; in other words, how close it is to the actual equipment currently in use in desirable job positions. Obsolete or irrelevant equipment, even if initially expensive, does not contribute to the quality of training. Factors such as facilities, which also impinge on the quality of training, are included in other variables. Diagrams 13, 14, and 15 relate quality of teaching to the three factors listed above.

$$QT = QT1(CT) \cdot QT2(SMAT) \cdot QT3(PEQP)$$

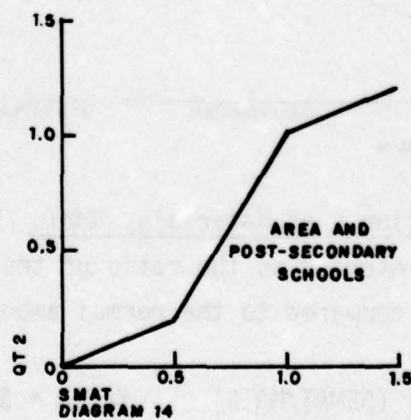
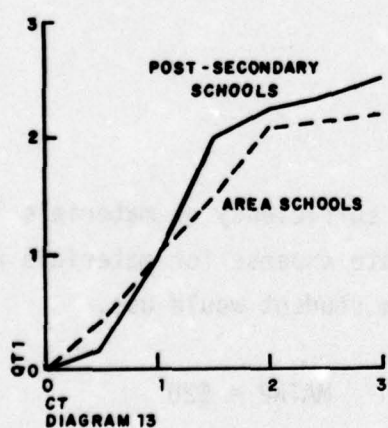
$$QT1A = f_1(CTA); 0.0, 3.0; 0.0/0.4/1.0/1.5/2.1/2.15/2.2$$

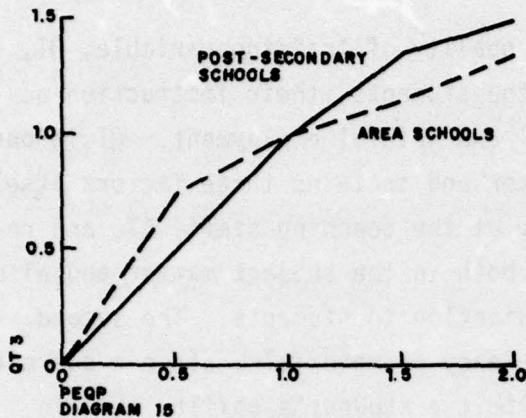
$$QT1P = f_2(CTP); 0.0, 3.0; 0.0/0.2/1.0/2.0/2.25/2.35/2.5$$

$$QT2 = f_3(SMAT); 0.0, 1.5; 0.0/0.2/1.0/1.2$$

$$QT3A = f_4(PEQPA); 0.0, 2.0; 0.0/.75/1.0/1.15/1.35$$

$$QT3P = f_5(PEQPP); 0.0, 2.0; 0.0/.50/1.0/1.35/1.5$$

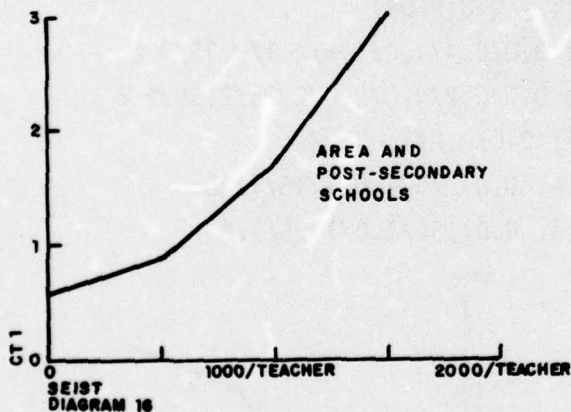




Competency of Teachers, CT. The competency of the Voc Ed teacher faculty is related here to the amount the State spends on in-service training, SEIST. This relationship is displayed in diagram 16.

$$CT = CT1(SEIST)$$

$$CT1 = f(SEIST); 0.0, 1500; 0.6/0.9/1.7/3.0$$



Sufficiency of Materials, SMAT. The sufficiency of materials is simply represented as the ratio of the State expense for materials per student as compared to the normal amount a student would use.

$$SMAT = (SEMAT/MATN)$$

$$MATNA = \$30$$

$$MATNP = \$20$$

Propriety of Equipment, PEQP. Equipment grows obsolete and breaks down if not replaced by the State expenditure for new equipment, SEEQP. The normal expense for equipment per year is EQPN. The replacement time, TOBS, is taken as six years. The value of PEQP in 1960 is assumed to be .60 for both the area and post-secondary schools.

$$d(\text{PEQP})/dt = -\text{PEQP}/\text{TOBS} + \text{SEEQP}/\text{EQPN}$$

$$\text{TOBS} = 6$$

$$\text{EQPNA} = \$400$$

$$\text{EQPNP} = \$150$$

Perceived Starting Wages, PSW. The variable PSW models two facets of the students' desire to enroll in vocational training. Some students, most interested in their immediate future, are concerned with the actual salary they can expect to receive directly after graduation. Others are concerned with how fast they can advance, or equivalently, how many years of apprenticeship or other on-the-job training they can bypass by attending and graduating from a vocational education program. In a sense, this is also a measure of how well the initial employer or union regards the training that the student received - measured in the hard terms of how many extra dollars a week vocational training is worth. Because the students are usually not aware of the average employer's policies in this regard, a delay of three years, called PTIME1, is included to allow time for information to filter down to the student body through person-to-person channels. The variable UAW, unskilled average wage, is used as a reference against which to gauge SWG, the starting wage for graduates. This is used solely as a reference point for the model - the students may well interpret salaries in other terms, for example, in terms of the price of a new car. The values of PSW in 1960 are taken to be 1.05 and 1.40 for the area and post-secondary schools, respectively.

$$\text{PSW} = \text{DELAY}(\text{SWG}/\text{UAW}, \text{PTIME1})$$

$$\text{PTIME1} = 3$$

Perceived Wage Ratio, PWR. Some students think more in terms of the final career positions rather than immediate starting salaries. The wage ratio between skilled and unskilled workers, delayed again by the time for information to reach students, measures this influence. The values of PWR in 1960 are taken to be 1.083 and 1.30 for the area and post-secondary schools, respectively.

$$\begin{aligned} \text{PWR} &= \text{DELAY}(\text{SAW}/\text{UAW}, \text{PTIME1}) \\ \text{PTIME1} &= 3 \end{aligned}$$

Perceived Skilled Unemployment Rate, PSUR. Another factor that influences a student's decision to attend a Voc Ed school is the unemployment rate for his prospective training speciality, as he perceives it. Since this figure is widely publicized, a delay in information, PTIME2, of only one year is used. The value of PSUR in 1960 is taken to be .0513 for both the area and post-secondary schools. This figure is based upon the ratio of unemployed skilled workers to the total labor force. SURS is the instantaneous skilled worker State unemployment rate.

$$\begin{aligned} \text{PSUR} &= \text{DELAY}(\text{SURS}, \text{PTIME2}) \\ \text{PTIME2} &= 1 \end{aligned}$$

Perceived Unskilled Unemployment Rate, PUUR. If the unskilled unemployment rate is, for any reason, significantly lower than the skilled rate, a young person considering Voc Ed training might wonder if he is training himself out of employment, and consequently be less apt to enroll. Likewise, a high unskilled unemployment rate would encourage people to enroll to gain employable skills. The value of PUUR in 1960 is taken to be .1087 for both the area and post-secondary schools. This figure is based upon the ratio of unemployed unskilled workers to

the total unskilled labor force. The same delay of one year in information is used. SURU is the instantaneous unskilled worker State unemployment rate.

$$\begin{aligned} \text{PUUR} &= \text{DELAY}(\text{SURU}, \text{PTIME2}) \\ \text{PTIME2} &= 1 \end{aligned}$$

Self-Esteem Factors, SEF. Self-esteem here is used to represent the purely psychological attitude that students have concerning a particular Voc Ed school. If neither the State, SSM, nor employers, ESM, do anything to maintain a high level of self-esteem, it will gradually decline until the students are apathetic about attending an individual Voc Ed school and enrollment consequently will drop. Five years is taken as typical of the time, ATIME, that it takes a good impression of a school to turn into a bad one. The factors included in SEF are, in addition, items such as quality of training or the condition of the facilities, both of which also have a great influence on students' attitudes. However, we include the influence of especially well-trained teachers in QT, rather than SEF, even though particular teachers may develop a rapport with students and increase their self-esteem. To repeat, SEF includes only the self-esteem factors connected with employer relations and the school's self-image. SEF is a cluster of variables of the same level as CM. The values of SEF in 1960 are taken to be .12 and .125 for the area schools and post-secondary schools, respectively.

$$\begin{aligned} \frac{d(\text{SEF})}{dt} &= -\text{SEF}/\text{ATIME} + \text{SSM} + \text{ESM} \\ \text{ATIME} &= 5 \end{aligned}$$

Employer Support for Morale, ESM. Besides direct financial expectations, students react to the psychological attitudes of those with whom they come in contact. ESM attempts to measure the positive attention that potential employers spend on vocational education students

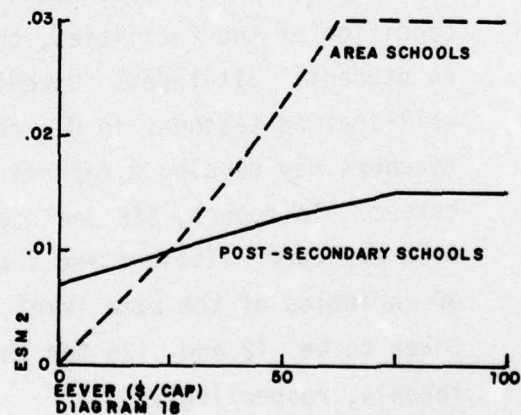
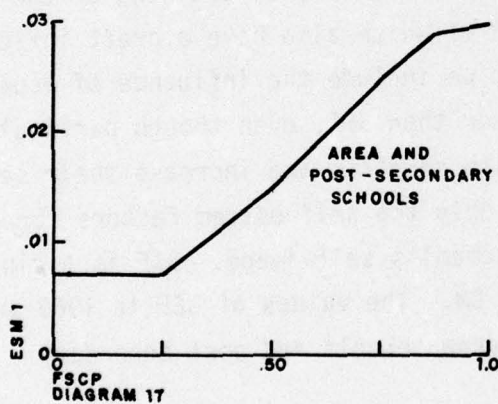
and prospective students. A student's self-esteem arising from these employer actions is measured by two variables: the fraction of students who are allowed into co-op programs, FSCP, and the expense incurred by the employers, EEVER, in the State to advise the Voc Ed administrators, teachers, and students (which includes such things as plant visits, advisory council participation, etc.). Diagrams 17 and 18 show the relationships of FSCP and EEVER to employer support for morale.

$$ESM = ESM1(FSCP) + ESM2(EEVER)$$

$$ESM1 = f_1(FSCP); 0.0 \ 1.0; .007/.007/.007/.011/.015/.02/.025/.029/.03$$

$$ESM2A = f_2(EEVERA); 0.0, 100.0; 0.0/.005/.01/.016/.0225/.03/.03/.03/.03$$

$$ESM2P = f_3(EEVERP); 0.0 \ 100.0; .007/.01/.013/.015/.015$$



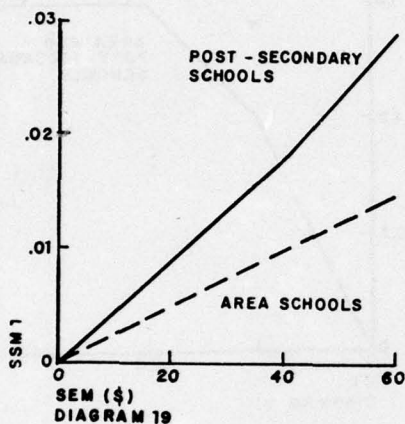
State Support for Morale, SSM. Students can have a positive attitude about an area Voc Ed school (or any other) provided the students regard it as a pleasant place to congregate. The State can influence this by providing materials or time for the students to work on individual projects, or on group projects for charitable organizations such

as churches, ecological groups, etc. Diagram 19 shows the relationship between State expenditure for morale, SEM, and SSM.

$$SSM = SSM1(SEM)$$

$$SSM1A = f_1(SEMA); 0.0, 60.0; 0.0/.005/.01/.015$$

$$SSM1P = f_2(SEMP); 0.0, 60.0; 0.0/.009/.018/.029$$



Vocational Education's Image in the State Administration's View, VEIS. Four factors are combined into the students' realization of the priority that the State government officials give to them and their education. If the schools are dirty and crowded, for example, not only will the physical surroundings be unpleasant, but also the students will realize that they are not considered highly by those in charge of the budget. Consequently, enrollment will decline. Diagrams 20, 21, 22, and 23 show the relationships (respectively) of public relations expense, PRE, quality of teaching, QT, maintenance rate, MR, and crowding ratio, CR, to the Voc Ed image in the State administrator's view.

$$VEIS = VEIS1(PRE) + VEIS2(QT) + VEIS3(MR) + VEIS4(CR)$$

$$VEIS1 = f_1(PRE); 0.0, 1.5; 0.0/3.0$$

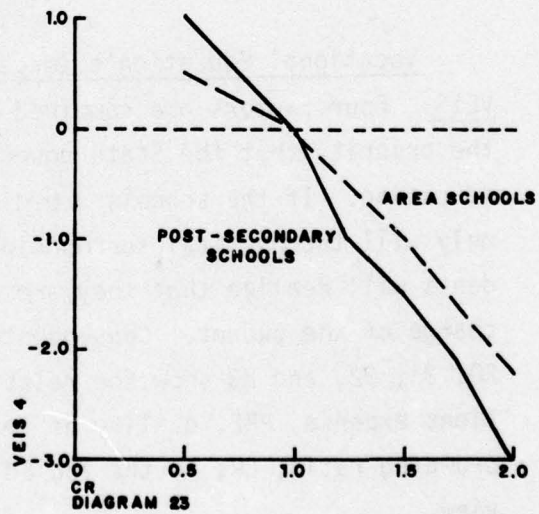
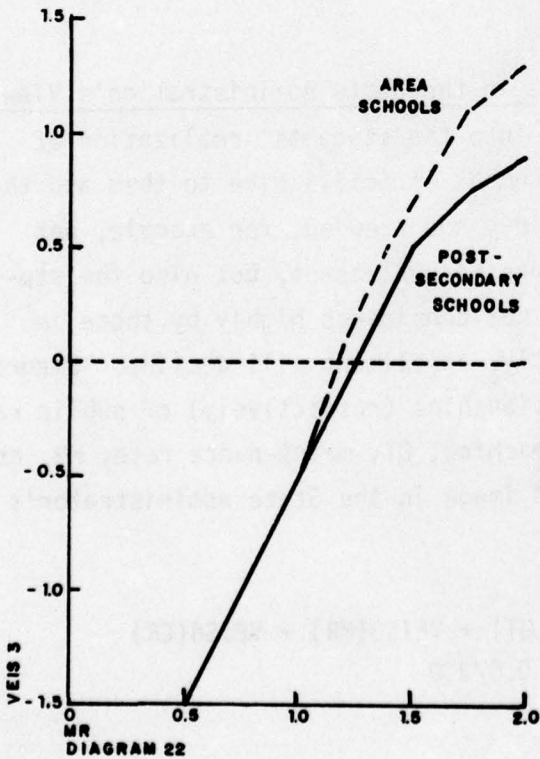
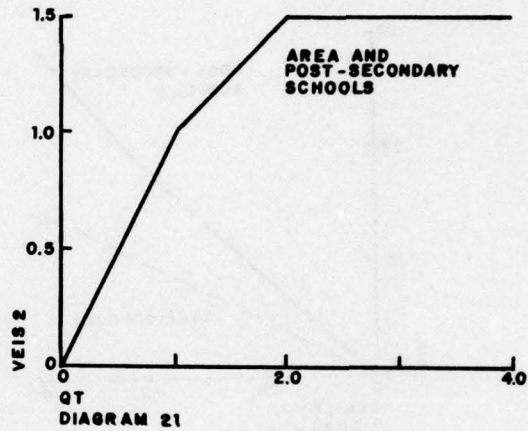
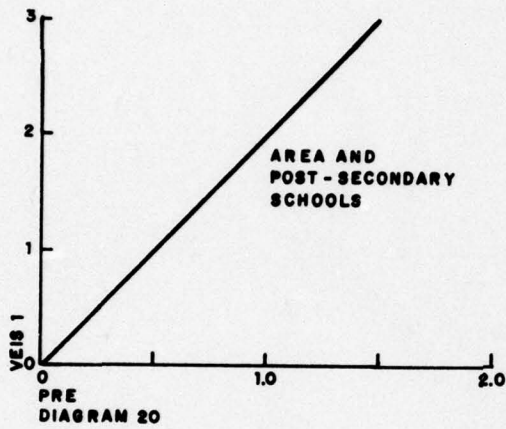
VEIS2 = $f_2(QT)$; 0.0, 4.0; 0.0/1.0/1.5/1.5/1.5

VEIS3A = $f_3(MRA)$; 0.0, 2.0; -1.5/-1.5/-1.5/-1.0/-0.5/0.0/0.5/.75/.90

VEIS3P = $f_4(MRP)$; 0.0, 2.0; -1.5/-1.5/-1.5/-1.0/-0.5/0.2/0.7/1.1/1.3

VEIS4A = $f_5(CRA)$; 0.5, 2.0; 0.5/.25/0.0/-.5/-1.0/-1.6/-2.2

VEIS4P = $f_6(CRP)$; 0.5, 2.0; 1.0/0.5/0.0/-1.0/-2.1/-3.0

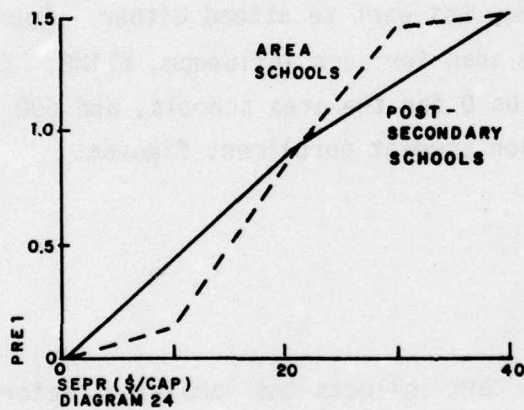


Public Relations Expense, PRE. Under public relations expense, we include the efforts of the State to improve the image of vocational education, in general, throughout the State. Students are directly influenced by counselors and indirectly by public relations directed at adults, through meetings with parents or guardians, or via the media. Diagram 24 shows the relationship between the State's public relations expenditures, SEPR, and the public relations factor, PRE, which influences overall attractiveness.

$$PRE = PRE1(SEPR)$$

$$PRE1A = f_1(SEPRA); 0.0, 40; 0.0/.15/.85/1.45/1.5$$

$$PRE1P = f_2(SEPRP); 0.0, 40; 0.0/.45/.90/1.2/1.5$$



Maintenance Rate, MR. Some students react to the condition of the school they attend; in particular, to the cleanliness, disorder, condition of paint, fixtures and other minor items, operating condition of the heating and plumbing, etc. The maintenance rate is simply the ratio of the actual state expense on maintenance, SEMT, to the absolute minimum at which the school can continue to function, MMR.

$$MR = SEMT/MMR$$

$$MMRA = \$4$$

$$MMRP = \$3$$

Crowding Ratio, CR. Students react to crowded conditions as all other people do; they avoid them if possible. Here crowding is measured by the number of shifts necessary to move the total number of students through the designed capacity of training stations, DCAP. For crowded conditions, CR approaches two. A delay in information of only one year is assumed. The values of CR are taken to be .6435 and .3135 for area schools and post-secondary schools, respectively, in 1960.

$$\begin{aligned} \text{CR} &= \text{DELAY}(\text{TVEE}/\text{DCAP}, \text{PTIME2}) \\ \text{PTIME2} &= 1 \end{aligned}$$

Past Enrollment, PEN. Past enrollment is used as a surrogate for peer pressure - if only a few of a student's older friends have gone to Voc Ed schools, the student may not want to attend either. Four years is used as an average time span for such influence, ETIME. The 1960 values of PEN are taken to be 0 for the area schools, and 600 for post-secondary schools, based upon student enrollment figures.

$$\begin{aligned} \text{PEN} &= \text{DELAY}(\text{TVEE}, \text{ETIME}) \\ \text{ETIME} &= 4 \end{aligned}$$

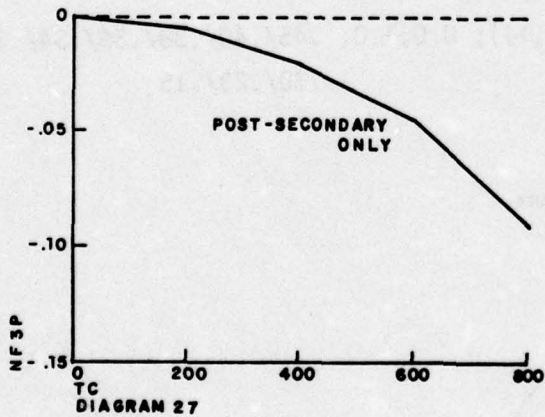
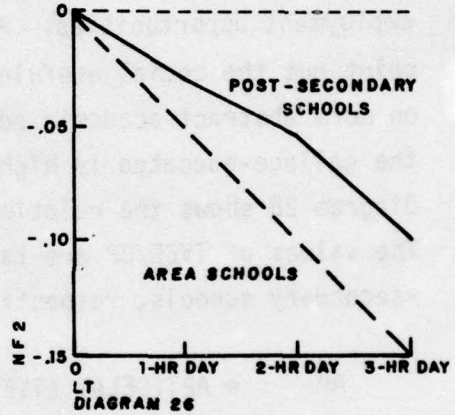
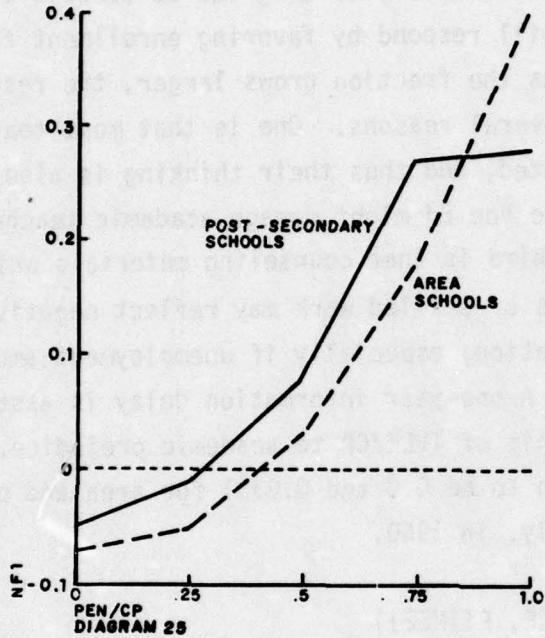
Nuisance Factors, NF. This term collects the remaining factors that influence a student's desire to attend a Voc Ed school. Besides the prejudice (AP), time (LT), and peer group factor (PEN/CP), students in post-secondary programs must pay tuition (TC). Diagrams 25, 26, and 27 show the relationships of PEN/CP, LT, TC, respectively, to the nuisance factor variables. CP represents the total potential Voc Ed applicants.

$$\begin{aligned} \text{NF} &= \text{AP} + \text{NF1}(\text{PEN}/\text{CP}) + \text{NF2}(\text{LT}) + \text{NF3}(\text{TC}) \\ \text{NF1A} &= f_1\{(\text{PEN}/\text{CP})\text{A}\}; 0.0, 1.0; -.07/- .05/.03/.18/.40 \\ \text{NF1P} &= f_2\{(\text{PEN}/\text{CP})\text{P}\}; 0.0 1.0; -.05/- .01/.08/.27/.28 \end{aligned}$$

NF2A = $f_3(LTA)$; 0.0, 3.0; 0.0/-.05/-.10/-.15

NF2P = $f_4(LTP)$; 0.0, 3.0; 0.0/-.03/-.055/-.10

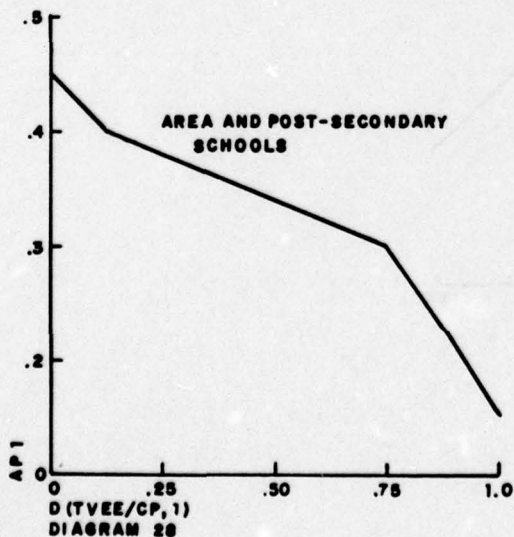
NF3P = $f_5(TC)$; 0.0, 800; 0.0/-.005/-.02/-.045/-.09



Academic Prejudice, AP. Academic prejudice reflects the influence of teachers in earlier grades on students' chances to opt for vocational training rather than a college preparatory or general curriculum education. If the fraction of students attending Voc Ed schools is small, teachers in aggregate will respond by favoring enrollment for students inclined to it, but as the fraction grows larger, the response will grow more negative for several reasons. One is that most teachers' training is college-oriented, and thus their thinking is also. A second is that a large swing to Voc Ed might damage academic teachers' employment opportunities. A third is that counseling materials which point out the social usefulness of skilled work may reflect negatively on more abstract academic education, especially if unemployment among the college-educated is high. A one-year information delay is assumed. Diagram 28 shows the relationship of TVEE/CP to academic prejudice. The values of TVEE/CP are taken to be 0.0 and 0.0351 for area and post-secondary schools, respectively, in 1960.

```

AP      = AP1(Delay {TVEE/CP, PTIME2})
PTIME2 = 1
AP1     = f(Delay {TVEE/CP,1}); 0.0,1.0; .45/.40/.38/.36/.34/.32
                                           .30/.23/.15
  
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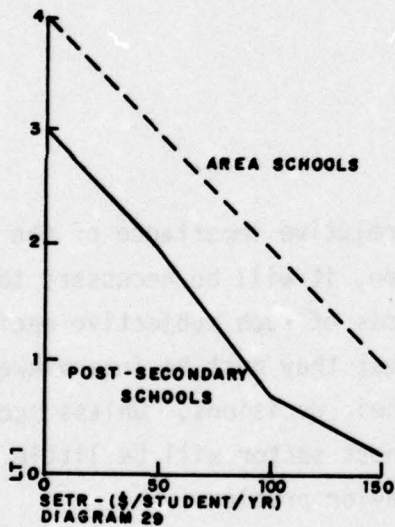


Lost Time, LT. The time lost for a student attending Voc Ed school compared with high school is dependent on State funding for transportation, SETR. Indirectly, it is also a function of the way the area schools are arranged and distributed throughout the State. Diagram 29 shows the relationship between SETR and lost time. (See figure 1 for locations of Rhode Island area schools.)

$$LT = LT_1(SETR)$$

$$LT_{1A} = f_1(SETRA); 0.0, 150; 4.0/3.0/2.0/1.0$$

$$LT_{1P} = f_2(SETRP); 0.0, 150; 3.0/2.0/.7/.2$$



Tuition Cost, TC. Tuition costs influence decisions by students to attend the junior college if they are significant fractions of the annual wage an applicant might expect to receive. The cost of education is defrayed, in part, by the State, and this amount is designated by SAT. TUITION is the total amount required to operate the school.

$$TC = TUITION - SAT$$

22

Program Applicants, PA. The total number of eligible students who apply to enter Voc Ed schools is modeled as the total number of possible applicants, CP, times the overall attractiveness fraction, OA.

$$PA = OA \cdot CP$$

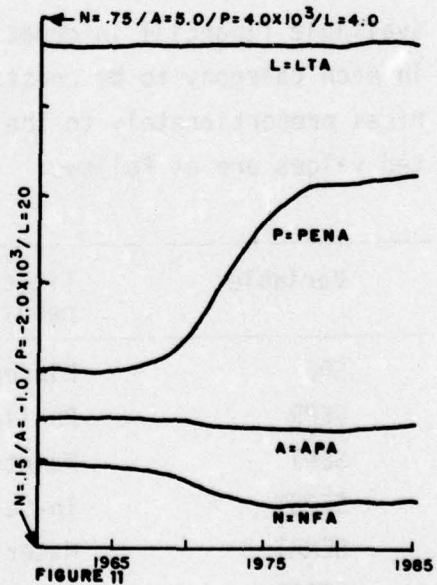
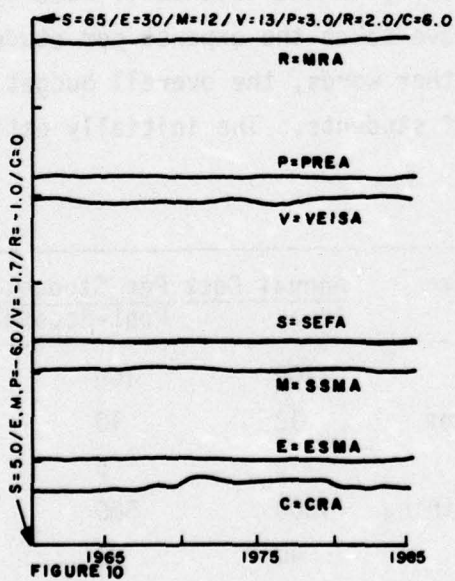
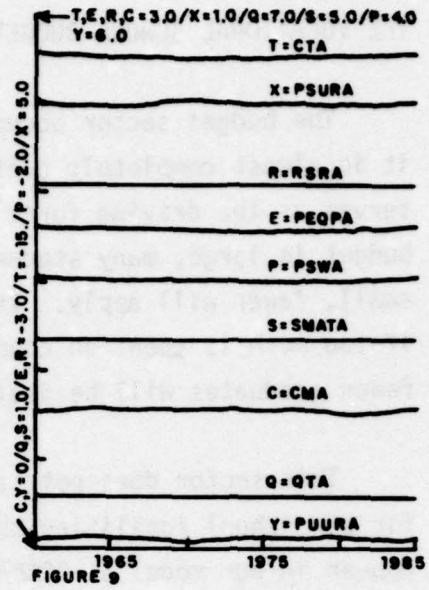
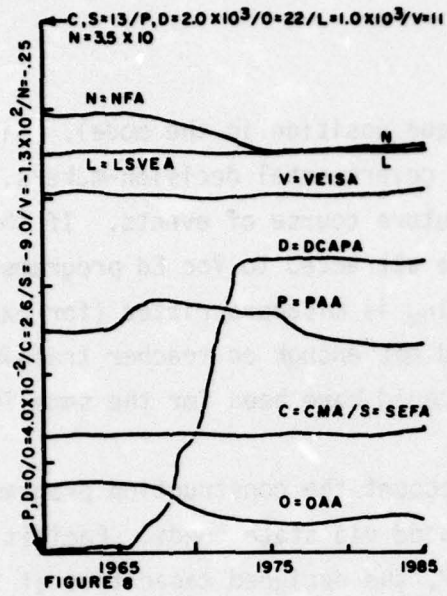
Locally Supported Voc Ed Students, LSVE. The number of students permitted to attend the area schools from local high schools is limited by the total amount that the local high school districts will support, MLSR.

$$LSVE = \text{Min} \{PA, \text{MLSR}\}$$

Attractiveness Sector Runs

To obtain realistic estimates of the relative importance of the above factors on a student's career decision, it will be necessary to go out to the student body. The only sources of such subjective decision making data are the students themselves; they must be interviewed, polled, or otherwise asked how they make their decisions. Unless such a procedure is carried out, the attractiveness sector will be little more than an exercise in structuring a behavior problem.

Until such interviews are completed and tabulated, there is little use in making attractiveness sector runs. In figures 8 through 11 we merely show that it is quite possible to produce a self-consistent set of initial conditions, parameters, etc. Each of the four factor clusters is displayed, along with the subordinate elements making up the cluster. In most cases the factor is constant in time, since the driving elements, the State budget categories of expenses per student, are assumed to be constant also. Only the components DCAPA and DCAPP vary, along with the Rhode Island population.



THE VOCATIONAL SCHOOL BUDGET SECTOR

The budget sector occupies a unique position in the model. Since it is almost completely controlled by governmental decision-makers, it serves as the driving force for the future course of events. If the budget is large, many students will be attracted to Voc Ed programs; if small, fewer will apply. If the funding is misappropriated (for example, if too much is spent on counseling and not enough on teacher training) fewer graduates will be trained than could have been for the same funds.

This sector does not take into account the construction programs for new school facilities that are funded via state bonds. Facilities appear in our model as DCAPA and DCAPP, the designed capacities of the two school systems as measured by the number of training stations.

For the purpose of the initial model, in the absence of readily available financial information, we have taken the expense per student in each category to be constant; in other words, the overall budget rises proportionately to the number of students. The initially estimated values are as follows:

Variable	Title (State expenditure for)	Annual Cost Per Student(\$)	
		Area	Post-Secondary
SPE	Placement	100	100
SEPR	Public Relations	12	10
SEMT	Maintenance	6	5
SEIST	In-Service Training	1000	500
SEMAT	Materials	40	25
SEEQP	Equipment	40	15
SETR	Transportation	65	50

THE LABOR SECTOR

Essentially, the labor sector consists of two nearly identical subsectors, one involving skilled workers; the other, unskilled. For both of these groups there is a separate employment process, which involves a pool of unemployed labor that responds to job openings caused by both industrial expansion and the retirement of employed workers. Furthermore, there are two migration rates for each subsector: one describing the number of workers who come to Rhode Island to take a particular job, and another describing the workers who come to Rhode Island to hunt for work. Both of these rates may be negative, of course, signifying emigration rather than immigration. For the purposes of this model, 8 percent of all technical workers, 50 percent of all managerial employees, 33 percent of all sales personnel, 50 percent of all service-providing workers, all craftsmen, and all clerical personnel are considered to be skilled. The unskilled consist of 67 percent of all sales personnel, 50 percent of all service providing workers, all operatives, and all labor types.

Connecting these two subsectors is the manpower sector, comprising federal programs that train either the employed or unemployed unskilled labor forces for skilled jobs. Another manpower function that applies only to the skilled subsector is the retraining program, which trains already-skilled workers for different skilled areas where more job opportunities exist. The location of the three manpower components is shown clearly in figure 12.

The student population sector connects to the labor sector as an input. Students graduating or dropping out of high school or out of a junior college program may immediately enter the labor market or, alternatively, may enlist in military service and receive vocational training there, enter a manpower program, or engage in a trade-oriented

apprentice program. Other students bypass the labor market entirely, going on to college or becoming housewives (or househusbands) and thereby completely escape the simulation model domain.

The balance between the unemployed and employed sections of the two sectors is largely controlled by the economic development sector, which provides the job growth rates. Separate rates are maintained for the two sectors although they are both determined by similar factors, such as tax rates and so on.

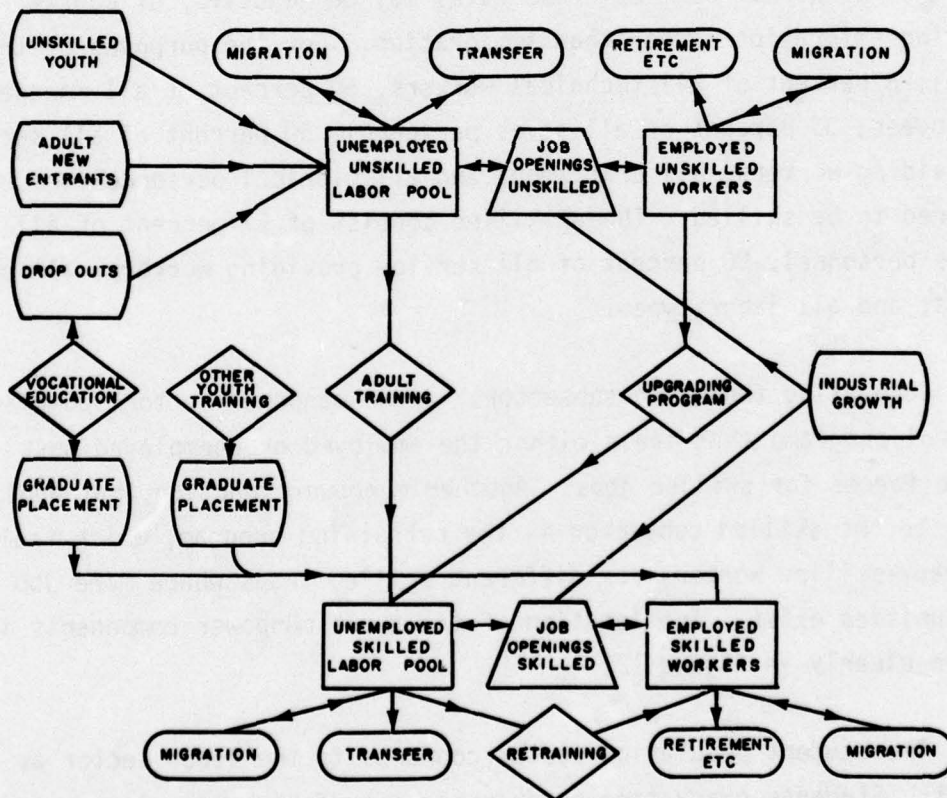


FIGURE 12

Variables Of The Labor Sector

The variables of the labor sector are as follows:

UULP	Unemployed Unskilled Labor Pool
EUW	Employed Unskilled Workers
UJO	Unskilled Job Openings
RUW	Retirement (etc.) of Unskilled Workers
MUW	Migration of Unskilled Workers
MUL	Migration of unemployed Unskilled Labor
TUUL	Transfer to Unemployable - Unskilled Labor
USLP	Unemployed Skilled Labor Pool
ESW	Employed Skilled Workers
SJO	Skilled Job Openings
RSW	Retirement (etc.) of Skilled Workers
MSW	Migration of Skilled Workers
MSL	Migration of unemployed Skilled Labor
TUSL	Transfer to Unemployable - Skilled Labor

Unemployed Unskilled Labor Pool, UULP. The number of employable but currently unemployed unskilled workers is represented by UULP. These people would typically hold laborer, operative, or service-type jobs. UULP is increased by two factors: the migration into the state of unemployed unskilled laborers, MUL; and high-school youth, graduating or dropping out, who do not find jobs, UHS. The size of the pool declines when additional job openings occur, UJO, and also decreases by the normal processes of attrition: death, aging beyond employable age, illness and accident, all combined under TUUL. Adult training programs, ATP, also decrease the size of the unskilled pool. The value of UULP is taken to be 16,300 in 1960.⁹

$$d(\text{UULP})/dt = \text{MUL} - \text{UJO} - \text{TUUL} + \text{UHS} - \text{ATP}$$

Employed Unskilled Workers, EUW. EUW measures the number of unskilled workers currently employed in the State. The added number of unskilled workers in the State each year is a fraction of the total number of employed unskilled workers; the growth rate is controlled by the rate of industrial expansion, IBUJGR. The value of EUW is taken to be 133,600 in 1960.¹⁰

$$d(EUW)/dt = IBUJGR \cdot EUW$$

Unskilled Job Openings, UJO. The number of jobs that are filled from the State's unskilled labor pool is measured by UJO. These jobs are controlled by industrial expansion and will be filled by in-state laborers unless an out-of-state worker migrates in to take the job, MUW, or unless a person formerly not in the labor market takes the job. In the 1960s a large number of women began or resumed work after not working for several years. They are represented by the term ANEUF. ANEUF is the per-year increase in the proportion of women from the population employed in unskilled jobs.¹¹ Other job openings are caused by retirements, etc., designated by RUW, and by the upgrading of workers, UPE.

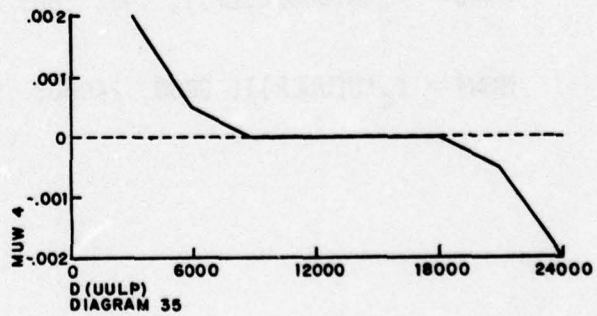
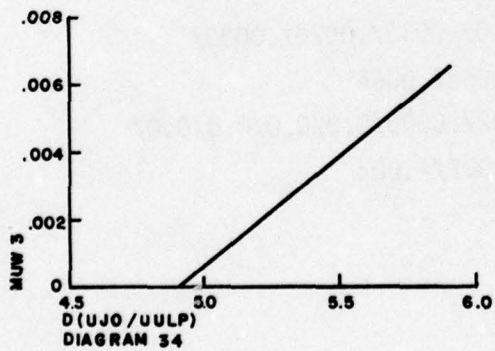
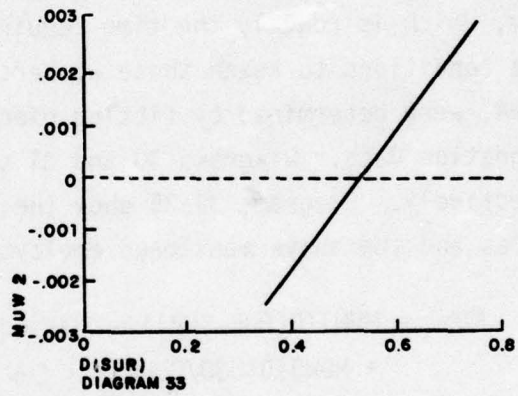
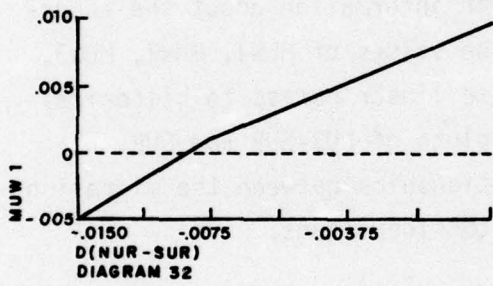
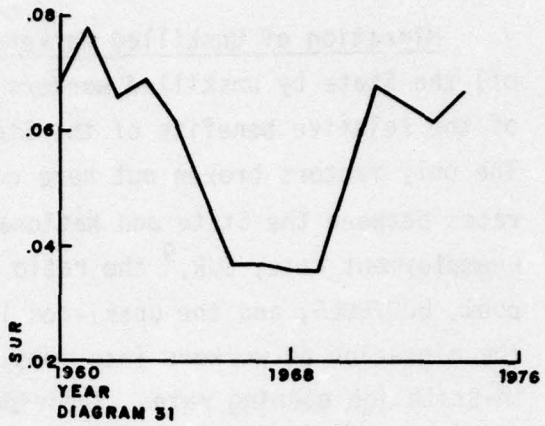
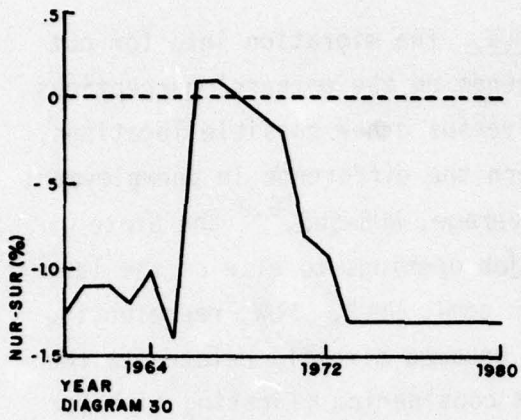
$$UJO = IBUJGR \cdot EUW - MUW + RUW + UPE - ANEUF \cdot RIPOP$$
$$ANEUF = .0003888.$$

Retirement of Unskilled Workers, RUW. Retirement and other attrition processes are assumed to occur at a constant rate per capita unskilled worker. The average rate, RRUN, reflects a mean working lifetime of 30 years.

$$RUW = RRUN \cdot EUW$$
$$RRUN = .033$$

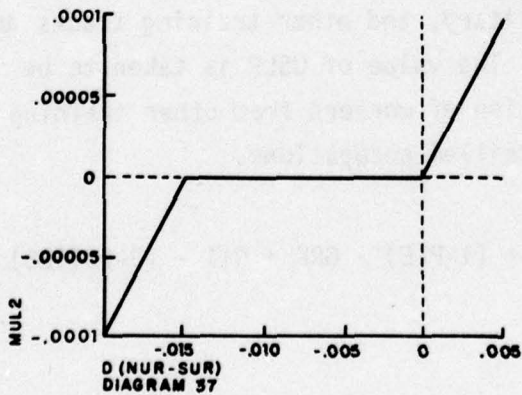
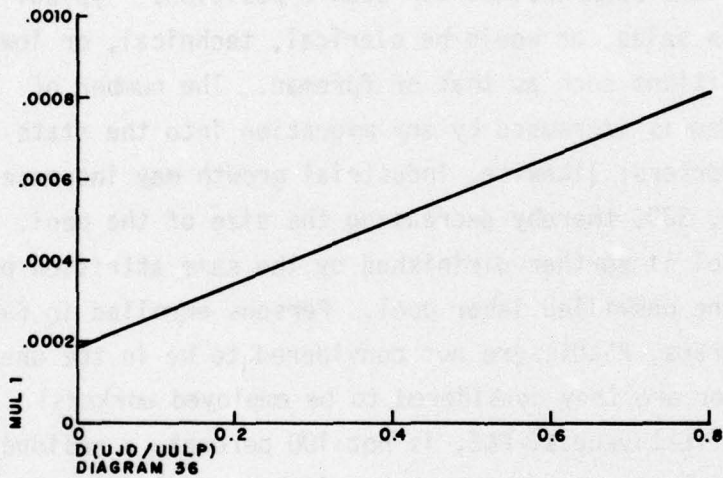
Migration of Unskilled Workers, MUW. The migration into (or out of) the State by unskilled workers depends on the workers' perceptions of the relative benefits of the State versus other possible locations. The only factors broken out here concern the difference in unemployment rates between the State and National average, $NUR-SUR$,^{6,9} the State unemployment rate, SUR ,⁹ the ratio of job openings to size of the labor pool, $UJO/UULP$, and the unskilled labor pool, $UULP$. MUW , representing the migration of workers into jobs, is assumed directly related to the in-State job opening rate. Individuals considering migrating into (or out of) Rhode Island in search of work are not immediately aware of the economic conditions within the State. The variables $D(NUR-SUR)$, $D(SUR)$, $D(UJO/UULP)$, and $D(UULP)$ are introduced to model a one- or two-year delay, which is roughly the time required for information about the economic conditions to reach these workers. The values of $MUW1$, $MUW2$, $MUW3$, $MUW4$, were determined by fitting piece-wise linear curves to historical migration data. Diagrams 30 and 31 show plots of $NUR-SUR$ and SUR , respectively. Diagrams 32-35 show the relationships between the migration rates and the above mentioned employment considerations.

$$\begin{aligned}
 MUW &= MUW1\{D(NUR-SUR)\} \cdot EUW + MUW2\{D(SUR)\} \cdot EUW \\
 &\quad + MUW3\{D(UJO/UULP)\} \cdot EUW + MUW4\{D(UULP)\} \cdot EUW \\
 MUW1 &= f_1\{D(NUR-SUR)\}; -.01125, 0.0; -.005/.001/.00525/.0095 \\
 MUW2 &= f_2\{D(SUR)\}; .035, .075; -.00247/.00302 \\
 MUW3 &= f_3\{D(UJO/UULP)\}; .49, .50; 0.0/.0013/.0026/.0039/ \\
 &\quad .0052/.0065 \\
 MUW4 &= f_4\{D(UULP)\}; 3000, 24000; .002/.0005/0.0/0.0/0.0/0.0/ \\
 &\quad -.0005/- .002
 \end{aligned}$$



Migration of Unemployed Unskilled Workers, MUL. The migration into Rhode Island of the unskilled unemployed is controlled by the same factors as for the unskilled employed. The variables $D(UJO/UULP)$ and $D(NUR-SUR)$ are the same as were defined for unskilled employed workers. Diagrams 36 and 37 show the relationships between the migration rates and the employment factors.

$$\begin{aligned}
 MUL &= MUL1\{D(UJO/UULP)\} \cdot EUW + MUL2\{D(NUR-SUR)\} \cdot EUW \\
 MUL1 &= f_1\{D(UJO/UULP)\}; 0.0, 0.8; .000189/.00082 \\
 MUL2 &= f_2\{D(NUR-SUR)\}; -.02, .005; -.0001/0.0/0.0/0.0/0.0/ \\
 &\quad .0001
 \end{aligned}$$



Transfer to Unemployable - Unskilled Labor, TUUL. The number of workers annually leaving the unskilled labor pool for reasons other than migration or finding other employment is modeled as a constant fraction of those in the labor pool. Working lifetime is assumed to be 30 years.

$$TUUL = TUULN \cdot UULP \qquad TUULN = .033$$

Unemployed Skilled Labor Pool, USLP. The unemployed skilled labor pool consists of all unemployed persons who have either worked in a skilled position or have been trained for such a position. Typical jobs held would be in sales, or would be clerical, technical, or low-level management positions such as that of foreman. The number of such people unemployed is increased by any migration into the state of unemployed skilled workers; likewise, industrial growth may increase skilled job openings, SJO, thereby decreasing the size of the pool. The skilled labor pool is further diminished by the same attrition processes that affect the unskilled labor pool. Persons enrolled in full-time retraining programs, RSL0T, are not considered to be in the unemployed labor pool (nor are they considered to be employed workers). Also, if placement effectiveness, PLE, is not 100 percent, a residual fraction of Voc Ed graduates enter the ranks of the unemployed. Finally, the skilled labor pool is increased by individuals who enter the labor market from manpower, military, and other training tracks and who are unable to find employment. The value of USLP is taken to be 7502 in 1960.⁹ FOTTES is the fraction of workers from other training tracks able to find employment at skilled occupations.

$$d(USLP)/dt = MSL - SJO - TUSL + (1-PLE) \cdot GRR + OTT \cdot (1-FOTTES) \\ - RSL0T$$

$$FOTTES = .80$$

Employed Skilled Workers, ESW. ESW measures the number of skilled workers currently employed in the State. The added number of skilled workers employed in the State each year is a fraction of the total number of employed skilled workers. This fraction, IBSJGR, relates to industries employing skilled workers and so differs from the unskilled growth rate, IBUJGR. The value of ESW is taken to be 138,000 in 1960.¹⁰

$$d(\text{ESW})/dt = \text{IBSJGR} \cdot \text{ESW}$$

Skilled Job Openings, SJO. Skilled job openings, like unskilled job openings, are a result of industrial growth in the skilled job area. The growth may be filled by the immigration of skilled workers into the jobs, MSW, or by the employment of a vocational education student directly upon graduation, PLE · GRR. Besides job openings arising from industrial growth, attrition processes (RSW) create vacancies to be filled from the labor pool. In the case of a negative industrial growth rate, such as might occur during a recession, SJO may be negative. Some fraction of skilled job openings are filled by individuals graduating from retraining (RSL0T), or by individuals entering the labor market from other training tracks (OTT) such as military service or trade apprenticeships. The fraction, F0TTES, relates to those graduates from other training tracks who are able to find employment as skilled workers. Late entrants into the labor force also fill some of these jobs just as with the unskilled labor force. ANESF is analogous to ANEU F in the unskilled labor sector and is designed to measure the increase in the number of these late entrants into the labor force.

$$\begin{aligned} \text{SJO} = & \text{IBSJGR} \cdot \text{ESW} - \text{MSW} - \text{PLE} \cdot \text{GRR} + \text{RSW} - \text{RSL0T} - \text{ATP} \\ & - \text{UPE} - \text{OTT} \cdot \text{F0TTES} - \text{ANESF} \cdot \text{RIPOP} \end{aligned}$$

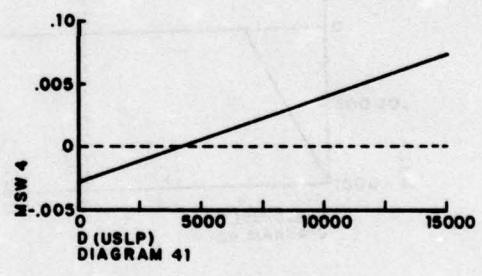
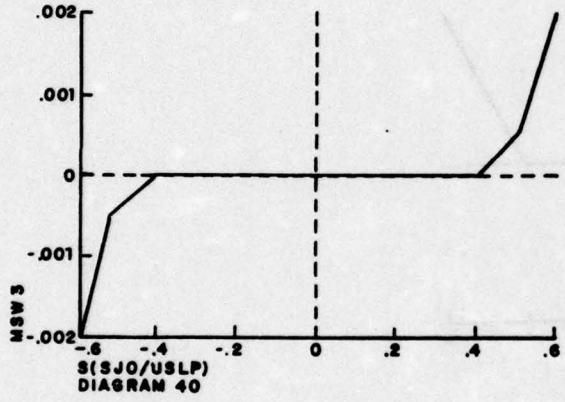
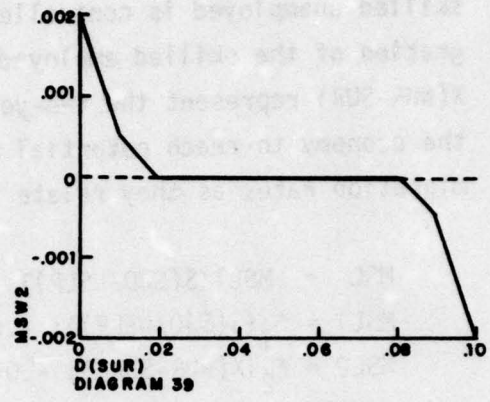
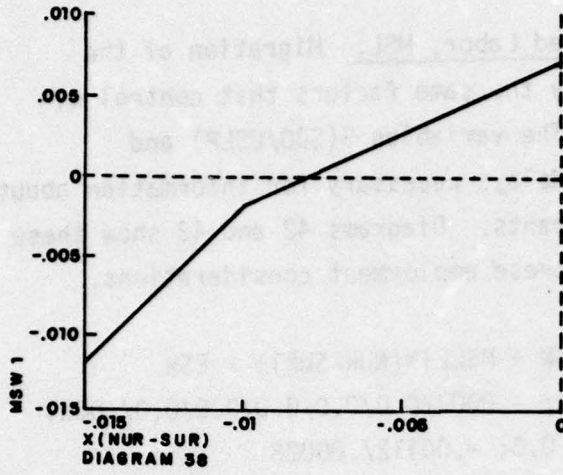
FOTTES = .80
 ANESF = .002056

Retirement of Skilled Workers, RSW. Retirement of skilled workers is modeled just as the retirement of unskilled workers. A working lifetime of 40 years is assumed. RRSN is the average attrition rate of skilled workers.

RSW = RRSN · ESW
 RRSN = .025

Migration of Skilled Workers, MSW. Skilled workers are assumed to behave just as unskilled workers in that they move into (or out of) the State in response to the difference in unemployment rates, the State unemployment rate, the ratio of job openings to the size of the labor pool, and the skilled labor pool. Skilled workers are assumed to have a higher mobility, which is reflected in the higher values of MSW1, MSW2, MSW3, and MSW4 as compared to the values of MUW1, MUW2, MUW3, and MUW4, respectively. The variables X(NUR-SUR), D(SUR), S(SJO/USLP), and D(USLP) serve a function similar to their counterparts for unskilled workers, with the same assumption that one or two years is needed for news of the economic conditions to be received. Diagrams 38, 39, 40, and 41 show the relationships between the migration factors and these employment conditions.

MSW = MSW1{X(NUR-SUR)} · ESW + MSW2{D(SUR)} · ESW +
 MSW3{S(SJO/USLP)} · ESW + MSW4{D(USLP)} · ESW
 MSW1 = f₁{X(NUR-SUR)}; -.015, 0.0; -.012/-.002/.0025/.007
 MSW2 = f₂{D(SUR)}; 0.0,0.1; .002/.0005/0.0/0.0/0.0/0.0/0.0/0.0/0.0/0.0/
 -.0005/- .002
 MSW3 = f₃{S(SJO/USLP)}; -6,6; -.002/- .0005/0.0/0.0/0.0/0.0/0.0/0.0/
 0.0/0.0/0.0/0.0/0.0/.0005/.002
 MSW4 = f₄{D(USLP)}; 0.0, 15,000; -.00273/.007586



Transfer to Unemployable - Skilled Labor, TUSL. The number of workers annually leaving the skilled labor pool for reasons other than migration or finding other employment is modeled as a constant fraction of those in the pool. Working lifetime is assumed to be 40 years.

$$TUSL = TUSLN \cdot USLP$$

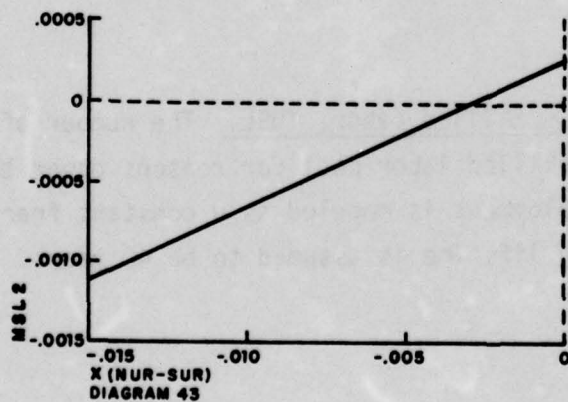
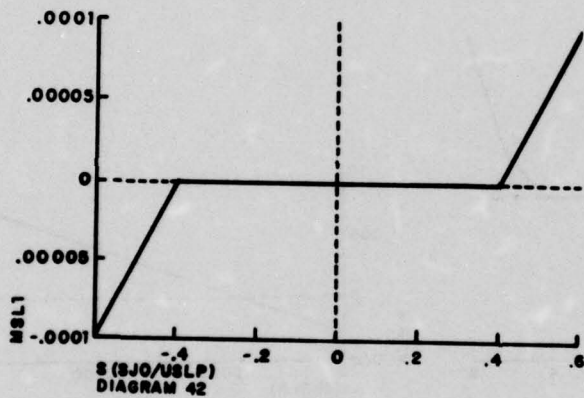
$$TUSLN = .025$$

Migration of Unemployed Skilled Labor, MSL. Migration of the skilled unemployed is controlled by the same factors that control migration of the skilled employed. The variables $S(SJO/USLP)$ and $X(NUR-SUR)$ represent the two-year delays necessary for information about the economy to reach potential migrants. Diagrams 42 and 43 show these migration rates as they relate to these employment considerations.

$$MSL = MSL1\{S(SJO/USLP)\} \cdot ESW + MSL2\{X(NUR-SUR)\} \cdot ESW$$

$$MSL1 = f_1\{S(SJO/USLP)\}; -.6, .6; -.0001/0.0/0.0/0.0/0.0/0.0/0.0001$$

$$MSL2 = f_2\{X(NUR-SUR)\}; -.015, 0.0; -.00112/.00028$$



THE MANPOWER SECTOR

In this sector of the model, only a brief sketch of manpower programs are included. The three programs listed here are merely functional representations of actually existing or planned programs. They are similar in that they all prepare workers for skilled jobs. They differ in the populations they serve: unemployed unskilled workers, employed but unskilled workers, and skilled workers needing training in an alternate skill area in order to find employment.

Variables Of The Manpower Sector

The variables of the manpower sector are:

- ATP Adult Training Programs
- RSL0T Retraining of Skilled Laborers into Other Trades
- UPE Upgrading Program Entrants

Adult Training Programs, ATP. The number of equivalent full-time students in adult training programs is measured by ATP. An adult attending at, for example, 1/4 time is regarded as 1/4 of a full-time student. The actual number of equivalent students is limited by a typical number attending and also by 1/8 of the unemployed unskilled labor pool.

$$ATP = \text{MIN}\{400, .125 \cdot \text{UULP}\}$$

Retraining of Skilled Labor into Other Trades, RSL0T. The number of unemployed skilled workers entering retraining programs each year is limited either by 2 percent of the unemployed skilled labor pool or by 10 percent of the number of skilled job openings. Both values are crude

estimates of the actual numbers. A three-year delay for training is assumed before an individual fills a skilled job opening.

$$RSLOT = \text{MIN}\{.02 \cdot USLP, .10 \cdot PSJO\}$$

Upgrading Program Entrants, UPE. The upgrading of employed unskilled workers is an option for the future should HEW upgrading programs become a reality. UPE is currently modeled as a constant fraction of the employed workers after the year 1985.

$$\begin{aligned} UPE &= 0 \text{ if } t < 1986 \\ &= .05 \cdot EUW \text{ if } t \geq 1986 \end{aligned}$$

THE MILITARY AND APPRENTICESHIP SECTOR

Despite the fact that virtually all the attention in this prototype model is on the training provided by vocational schools, there are other major sources of trained workers which may actually outweigh the contribution of these schools. The first source to be considered is the military services. Through their training programs, they provide the nation, and Rhode Island in particular, with large numbers of people trained in electronics, mechanical technology, medical services, and many other skilled areas. Similarly, there are apprenticeship programs run by unions as well as in-plant training programs conducted by employers within the State. Lastly, there are proprietary technical schools which provide specialized vocational training to those willing to pay the tuition.

In order to obtain an initial model with the requisite detail in the vocational school programs, it was necessary to model all these

alternative training programs as one lumped operation. Furthermore, as noted below, the inner-actions of the program were simplified to an absolute minimum.

Other Training Tracks, OTT. OTT measures the number of students who annually enter other training programs such as trade apprenticeships, military service, or non-public schools for the purpose of gaining a vocational education. The model also assumes that, to the first approximation, these programs change slowly, and that the same number of trainees graduate (or are discharged, become journeymen, etc.) each year as enter the programs. Also, for convenience, only successful entrants are counted; those who quit the programs before completion are described in the model as going directly into unemployment or the labor force. OTTDHN, OTTDJN, and OTTHN represent the fraction of dropouts from high school and junior college and of graduates from the general curriculum who enter other training tracks.

$$\begin{aligned} \text{OTT} &= \text{OTTDHN} \cdot \text{TADH} + \text{OTTDJN} \cdot \text{TADJ} + \text{OTTHN} \cdot \text{GCSG} \\ \text{OTTDHN} &= .40 \\ \text{OTTDJN} &= .02 \\ \text{OTTHN} &= .50 \end{aligned}$$

THE INDUSTRIAL GROWTH SECTOR

Industrial growth is obviously a key determinant of the need for skilled labor in Rhode Island. However, rather than model the features that would be examined within the State to influence growth (such as mortgage guarantees, tax advantages, etc.) and then model the response of business to these incentives, we have elected to accept projected growth rates, IBSJGR and IBUJGR. For the purpose of this initial model

we take the growth rate of skilled jobs to be IBSJGRVDFG (diagram 44) and for unskilled jobs to be IBUJGRVDFG (diagram 45) unless the respective labor pools drop below a specified level. Earlier growth rates were obtained from historical sources.^{10,12}

$$\begin{aligned} \text{IBSJGR} &= \text{IBSJGRVDFG} && \text{if USLP} \geq 1500 \\ &= -.03 && \text{if USLP} < 1500 \end{aligned}$$

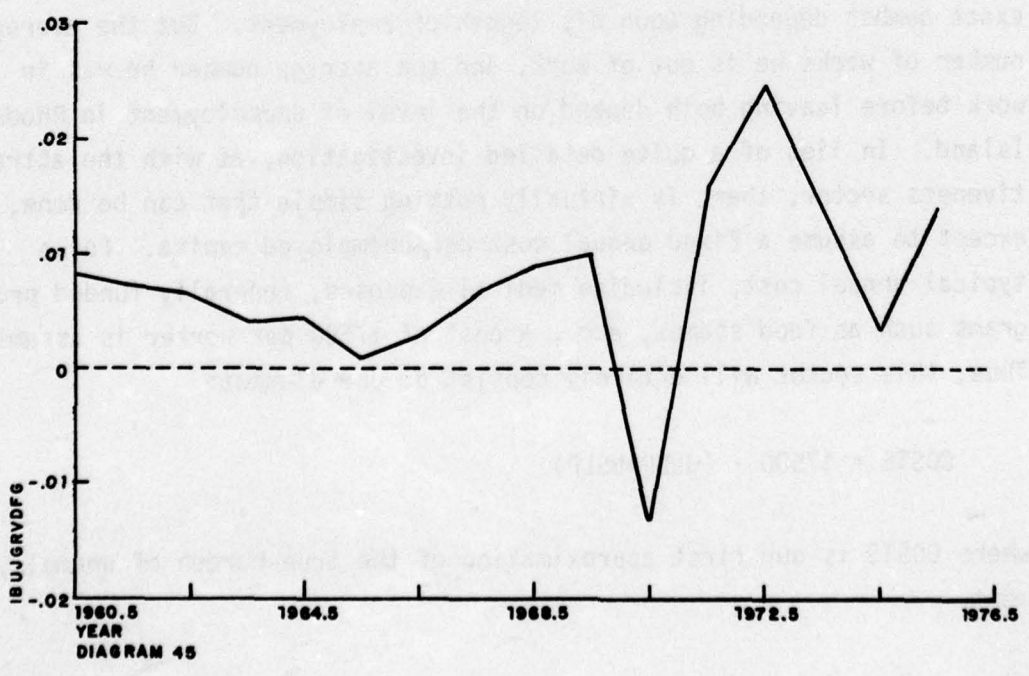
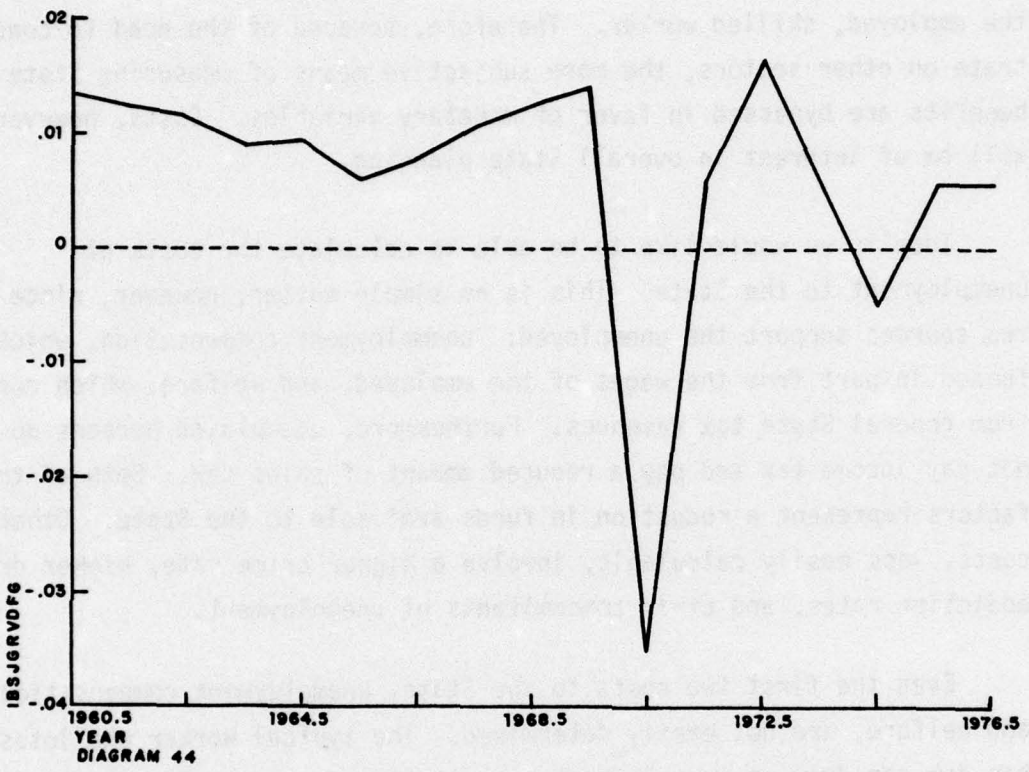
$$\begin{aligned} \text{IBUJGR} &= \text{IBUJGRVDFG} && \text{if UULP} \geq 1500 \\ &= -.03 && \text{if UULP} < 1500 \end{aligned}$$

$$\begin{aligned} \text{IBSJGRVDFG} = f_1(t); 1960, 1975; &.013284/.012362/.011478/ \\ &.00912/.009487/.006129/ \\ &.007804/.010650/.012648/ \\ &.014084/-.03537/.005884/ \\ &.016407/.005833/-.00488/.005735 \end{aligned}$$

$$\begin{aligned} \text{IBUJGRVDFG} = f_2(t); 1960, 1975; &.008218/.007274/.006528/.003955/ \\ &.004333/.000902/.002915/.006329/ \\ &.00865/.010048/-.01335/.015714/ \\ &.02472/.014167/.003646/.01411 \end{aligned}$$

THE STATE BENEFITS SECTOR

The remaining sector of the model measures, in dollars, the human benefits of vocational training. Using dollars as a measurement of quality of life is an admittedly deficient way of calculating the benefits that the State receives in terms of reduced unemployment rolls and decreased welfare costs, but no other measure is readily available for computation of such things as the increased self-satisfaction of



the employed, skilled worker. Therefore, because of the need to concentrate on other sectors, the more subjective means of measuring State benefits are bypassed in favor of monetary variables. Costs, however, will be of interest in overall State planning.

Ideally we would like to be able to calculate the costs of unemployment to the State. This is no simple matter, however, since two sources support the unemployed: unemployment compensation, which is funded in part from the wages of the employed; and welfare, which comes from general State tax revenues. Furthermore, unemployed persons do not pay income tax and pay a reduced amount of sales tax. Both of these factors represent a reduction in funds available to the State. Other costs, less easily calculable, involve a higher crime rate, higher drug addiction rates, and other concomitants of unemployment.

Even the first two costs to the State, unemployment compensation and welfare, are not easily determined. The typical worker who loses his job can draw on unemployment compensation for several weeks, the exact number depending upon his length of employment. But the average number of weeks he is out of work, and the average number he was in work before leaving both depend on the level of unemployment in Rhode Island. In lieu of a quite detailed investigation, as with the attractiveness sector, there is virtually nothing simple that can be done, except to assume a fixed annual cost per unemployed capita. For a typical annual cost, including medical expenses, federally funded programs such as food stamps, etc., a cost of \$7500 per worker is assumed. Thus, this sector will entirely consist of one element:

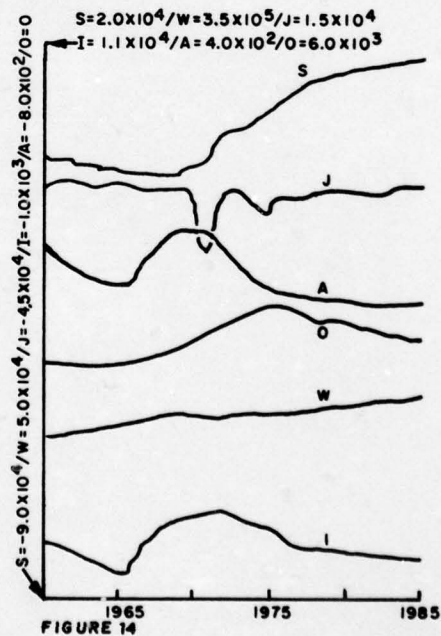
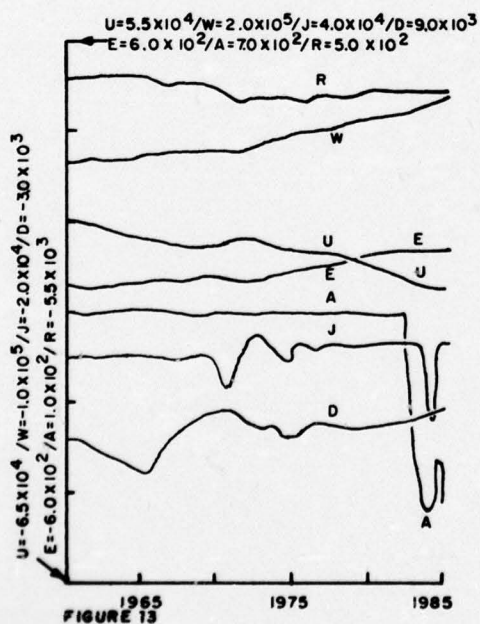
$$\text{COSTS} = \$7500 \cdot (\text{UULP} + \text{USLP})$$

where COSTS is our first approximation of the true burden of unemployment.

Runs Of The Remaining Sectors

Because the four preceding sectors are so small as to be not relevant when considered separately, they are run combined with the labor sector. However, the other major sectors (Population, Attractiveness and School Budget) are uncoupled from the labor market, and Voc Ed graduation levels are replaced by reasonable estimates based upon historical data.

Figures 13 and 14 show the outcomes of the two labor subsections. In the first, the unskilled portion is shown. The unemployed labor pool, marked with symbol U, declines slowly until 1966, at which time it grows even more slowly until 1972. Shortly thereafter, the Navy cutback around 1974 raises unemployment even beyond 1960 levels. The model forecast, based on the industrial growth rate discussed in the Industrial Growth Sector, indicates an increase in unemployment.



Migration of unskilled labor (symbol E) is a small fraction of total migration in Rhode Island, but it reflects the comparative advantages of living here, and how these advantages change over time. Emigration occurs until 1966, followed by a four-year period of immigration, which is followed by an unchanging emigration rate.

The skilled subsection in figure 14 behaves similarly. However, the unemployed skilled labor pool (symbol S) declines through the historical period, leaps upwards in 1974, and again declines after 1975.

CHAPTER 6 MODEL EXPERIMENTS

All the previous sectors were combined into a complete model, which is referred to in this chapter as the standard version. Many runs were made with the standard version and several alternatives of it in which certain exogenous assumptions were changed. First, the format of the output in terms of the standard run are presented. The trends of the basic model variables are shown in figures 15 and 16.

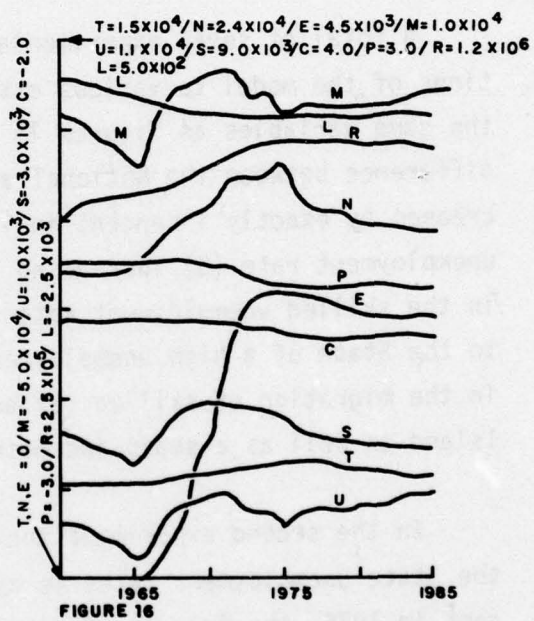
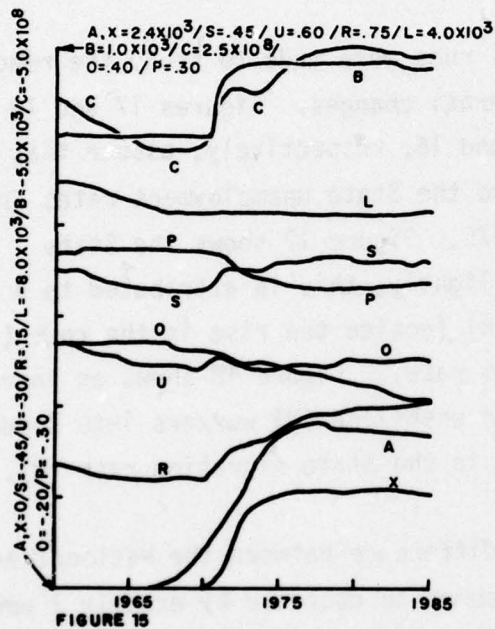
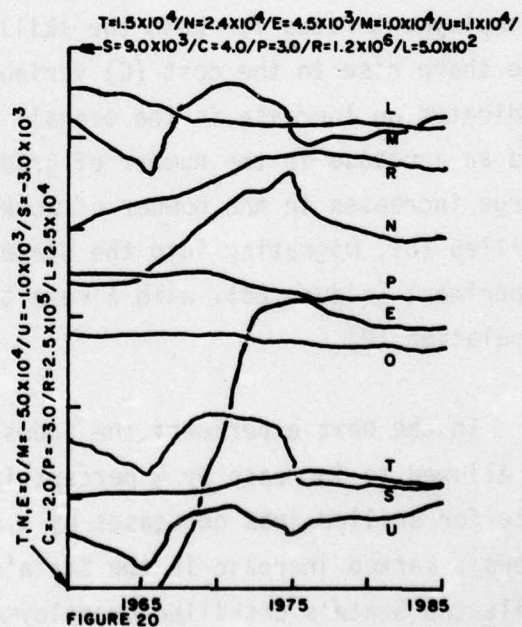
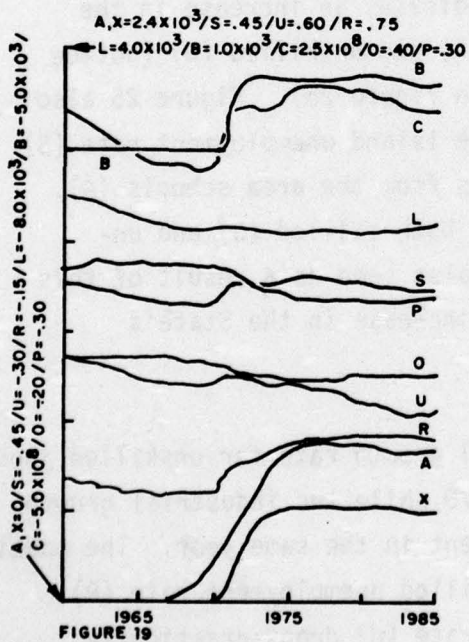
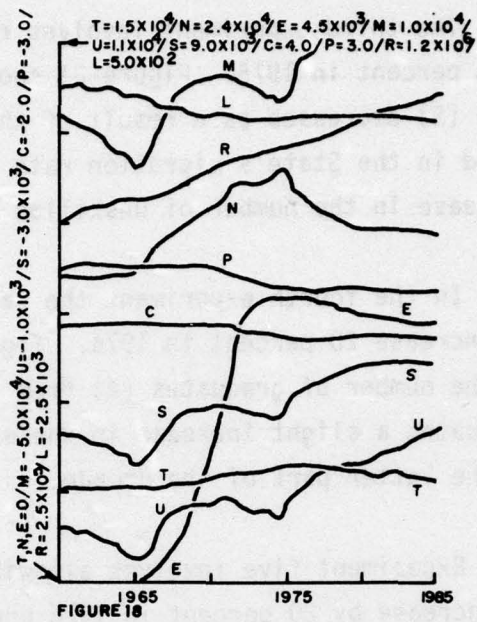
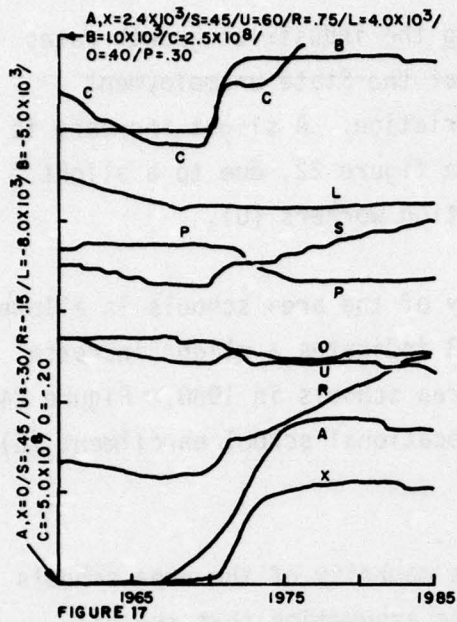


Figure 15 shows that the numbers of skilled graduates from the area schools (A) and from the junior college (X) increase steadily through 1974 and then level off as the skilled unemployment rate (R) climbs, thereby making Voc Ed less attractive in both the area schools (O) and in post-secondary education (P). We can also see that as unemployment increases, the cost to the state (C) for unemployment compensation,

welfare, and other programs increases. Figure 16 complements the variables of figure 15, and illustrates the effect of the State's history of high unemployment (compared to the Nation as a whole) on its migration rate (M). It also indicates that the State's population (R) will level off, assuming a decreasing birth rate. At the same time the number of students in the ninth grade throughout the State (N) will also decrease. The increasing unemployment rate is responsible for the slight dip in the model variables CMA (C) and CMP (P) which represent career motivation for potential students to enter the Voc Ed area schools and junior college programs, leading to the reduction in graduates seen in figure 15.

A total of seven experimental runs were made to study the reactions of the model to various external changes. Figures 17 and 18 with the same variables as figures 15 and 16, respectively, assume that the difference between the National and the State unemployment rates increases by exactly 1 percent in 1975. Figure 17 shows the State unemployment rate (S) increasing slightly; this is attributed to a rise in the skilled unemployment rate (R) (notice the rise in the cost (C) to the State of a high unemployment rate). Figure 18 shows an increase in the migration of skilled (S) and unskilled (U) workers into Rhode Island as well as a sharp increase in the State migration rate (M).

In the second experiment the difference between the National and the State unemployment rates is assumed to decrease by exactly 1 percent in 1975, the inverse of experiment one. A slight decrease in the unemployment rate (S) is noted in figure 19. This is due principally to a decrease in the skilled unemployment rate (notice that the cost variable (C) decreases). Figure 20 indicates that skilled workers (S) begin to emigrate from the State, while the State's population (R) decreases slightly.

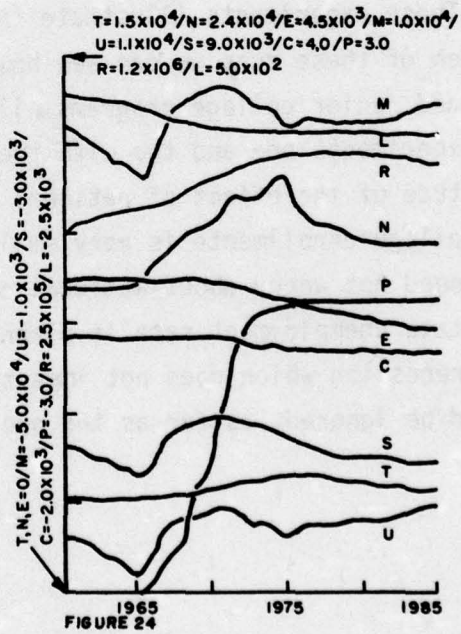
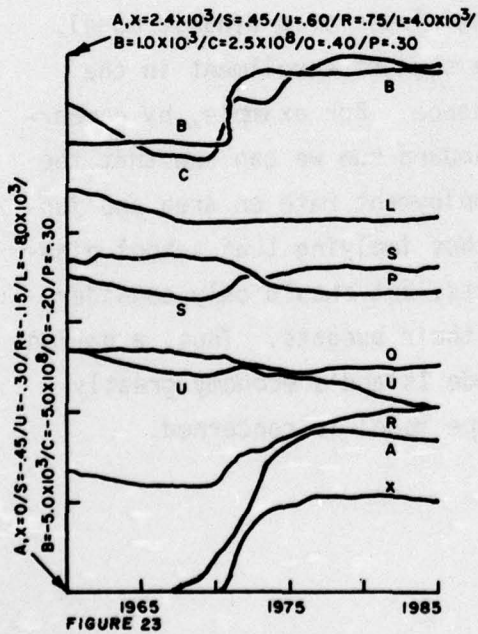
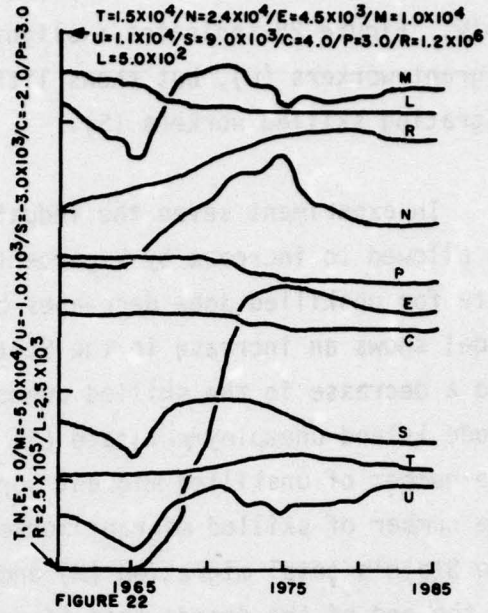
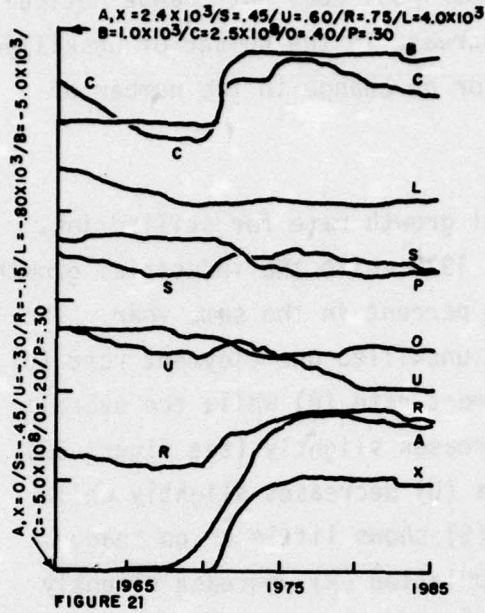


The third experiment involves raising the industrial growth rates by $\frac{1}{2}$ percent in 1975. Figure 21 shows that the State unemployment rate (S) decreases as a result of this variation. A slight increase is noted in the State's migration rate (M) in figure 22, due to a slight increase in the number of unskilled migrating workers (U).

In the fourth experiment the capacity of the area schools is allowed to increase 20 percent in 1976. Figure 23 indicates a slight increase in the number of graduates (A) from the area schools in 1980. Figure 24 indicates a slight increase in the area vocational school enrollment (E) in the latter part of the decade.

Experiment five involves allowing the capacity of the area schools to increase by 20 percent in 1976 under the assumption that the difference between the National and the State unemployment rates increases by exactly 1 percent in 1975. The run indicates an increase in the unemployment rates for both the skilled (R) and unskilled (U) (notice the sharp rise in the cost (C) variable in figure 25). Figure 25 also indicates an increase in the overall Rhode Island unemployment rate (S) and an increase in the number of graduates from the area schools (A). Large increases in the number of workers, both skilled (S) and unskilled (U), migrating into the State is also seen as a result of this experiment (figure 26), with a resulting increase in the State's population (R).

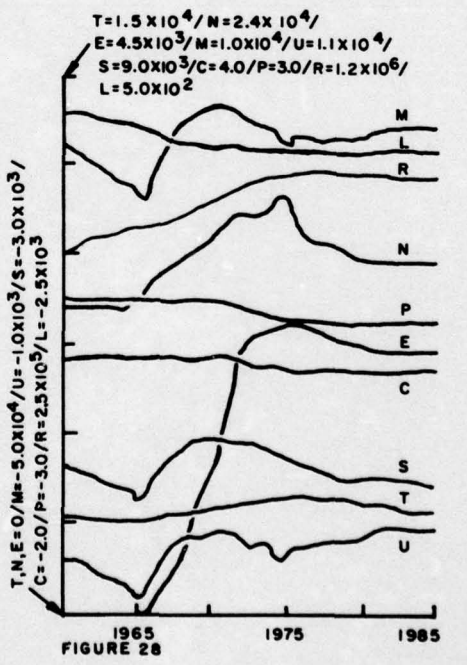
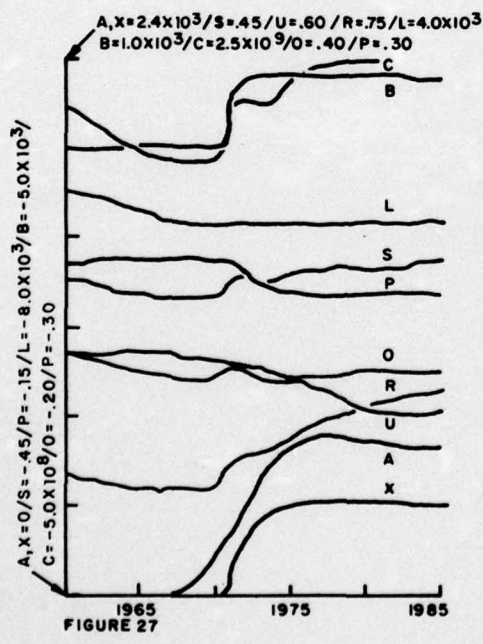
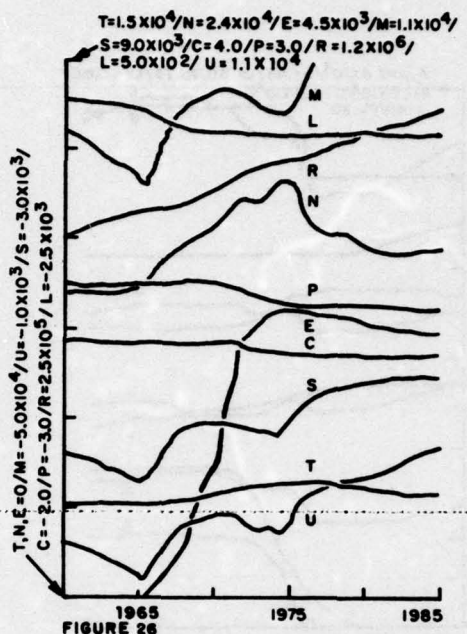
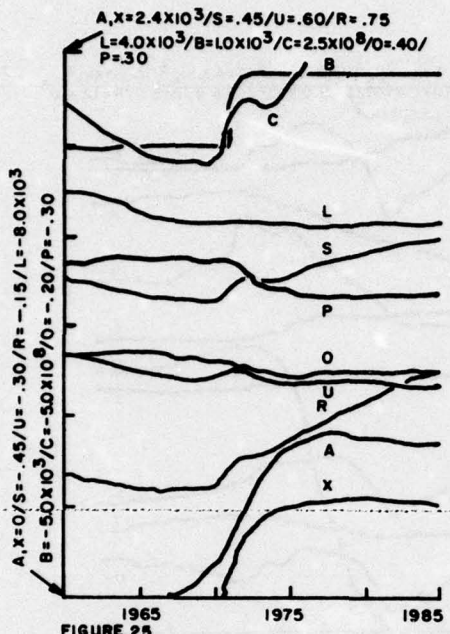
In the next experiment the industrial growth rate for unskilled jobs is allowed to increase by $\frac{1}{2}$ percent in 1975 while the industrial growth rate for skilled jobs decreases by $\frac{1}{2}$ percent in the same year. The model shows a marked increase in the State's skilled unemployment rate (R) while the State's unskilled unemployment rate (U) drops drastically. The overall Rhode Island unemployment rate (S) increases only slightly

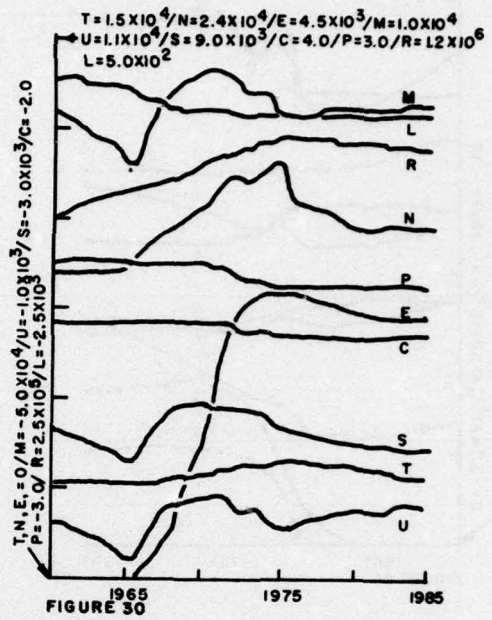
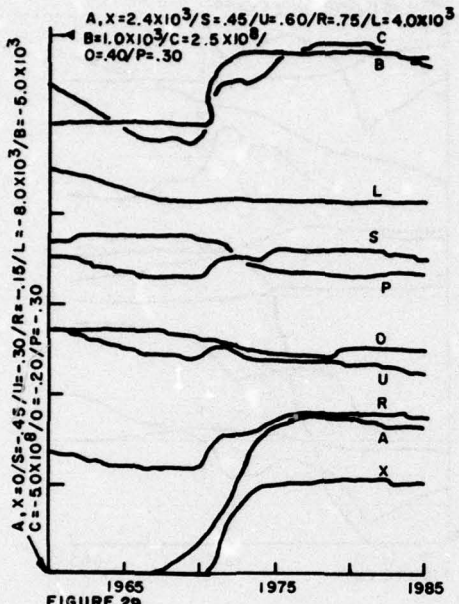


(see figure 27) since the composite labor pool does not change noticeably. Figure 28 indicates a slight increase in the number of unskilled migrant workers (U), but shows little or no change in the number of migrating skilled workers (S).

In experiment seven the industrial growth rate for skilled jobs is allowed to increase by $\frac{1}{2}$ percent in 1975 while the industrial growth rate for unskilled jobs decreases by $\frac{1}{2}$ percent in the same year. The model shows an increase in the State's unskilled unemployment rate (U) and a decrease in the skilled unemployment rate (R) while the overall Rhode Island unemployment rate (S) decreases slightly (see figure 29). The number of unskilled migrant workers (U) decreases slightly while the number of skilled migrant workers (S) shows little or no change. The State's total migration (M) and population (R) decrease slightly at the end of the decade (see figure 30).

These experiments illustrate the usefulness of a dynamic model. In each of these runs we can see how the student enrollment in the area and junior college programs will change. For example, by comparing experiments one and two with the standard run we can see that the magnitude of the effect of national unemployment rate on area and junior college enrollments is very small, thus implying that school planners need not worry about National effects, but should only consider the State unemployment rate in planning their budgets. Thus, a nationwide recession which does not impact Rhode Island's economy greatly should be ignored, as far as the prototype model is concerned.





CHAPTER 7

SENSITIVITY ANALYSIS OF THE BUDGET SECTOR

In the standard run, and in all seven experiments of the last chapter, area school enrollments declined after 1977, both as a result of the declining school-age population and the declining unemployment levels of skilled workers in Rhode Island. In order to maintain enrollments in the area schools, a State school administrator would have to make the vocational programs more attractive to individual students. How could he accomplish this at a minimum cost to the state? Should spending for counseling, materials, morale, in-service training, or some other areas be increased; or are some of these items unimportant, in fact, to a student's choice of career?

Dynamic models are extremely well-suited to analyze these effects, both for short-term and long-term results. By doing experiments of the kind called sensitivity tests, each budget factor can be evaluated to determine the degree of its influence on student enrollment. To illustrate this method we evaluated the effects of a 25 percent increase in each of eight factors. Some proved inconsequential, but three of them: State expense for in-service training, public relations, and maintenance indicated significant changes in enrollment.

The following table shows the percentage change in 1985 enrollments given a 25 percent increase in the budget categories beginning in 1975. Note that since some of the expenses are very small to begin with, the effectiveness of a dollar is often magnified.

Budget Category	Dollar Change	Number of Students Increase	Students Dollars	Percentage Sensitivity
SEIST	250	335	1.34	61.61
SEMAT	10	75	7.5	13.79
SEEQP	10	75	7.5	13.79
SEM	7.50	75	10.0	13.79
SEPR	3	225	75.0	41.38
SEMT	1.50	185	123.33	34.02
SETR	16.25	110	6.77	20.23

In this table the expenses occur annually from 1975 onward, and the enrollment is evaluated in 1985. Please remember that these figures are based only on interim estimates of student preferences. They show the type of results to be obtained from the model once the required interview and compilation work is completed.

CHAPTER 8 CONCLUSIONS

This report has presented a working model of the Rhode Island Vocational Education System, coupled to the State's labor market and economic development programs. It is capable of showing the interactions between migration, unemployment, industrial growth, school graduation rates, and a host of other factors. It is designed to be able to show the number of dollars the State will save in long-term welfare and unemployment costs for every dollar it invests in the vocational school budget.

The model was developed with very limited funds and does not have in it the necessary data to make these projections accurate. It is a prototype designed for demonstration purposes, and has served to plan and correct initial misconceptions about the structure of the many relationships involved in an educational-economic system. We are, in essence, following the advice of Gibson³ who explained that in order to produce the best model at lowest cost, one should first put together an interim version allowing many weaknesses to exist, since experience with the model itself usually yields the most insight into how it should be structured.

REFERENCES

1. H.R. Hamilton, et al., Systems Simulation for Regional Analysis: An Application to River Basin Planning, MIT Press, Cambridge, 1969.
2. Jobs, People and Land, Center for Real Estate and Urban Economics, Special Report No. 6, University of California, Berkeley, 1968.
3. J.E. Gibson, "A Philosophy of Urban Simulations," IEEE Transactions on Systems, Man and Cybernetics, Vol. SMC-2, No. 2, April 1972.
4. R.E. Markland and P.J. Grandstaff, "Analyzing Change in a Small-Area Economy Using Computer Simulation," Simulation and Games, Vol. 5, No 3. September 1974.
5. N.J. Glickman, "An Econometric Forecasting Model for the Philadelphia Region," Journal of Regional Science, Vol. 11, No. 1, 1971.
6. Rhode Island Basic Economic Statistics, Rhode Island Development Council, Providence, 1972.
7. Statistical Tables {1965-1973}, Rhode Island Department of Education, Providence.
8. Public Higher Education Enrollment Report, 1973-1974, Office of Planning and Management, Rhode Island Department of Education, Providence, May 1974.
9. A Rhode Island Report, Rhode Island Development Council, Providence, January 1974.

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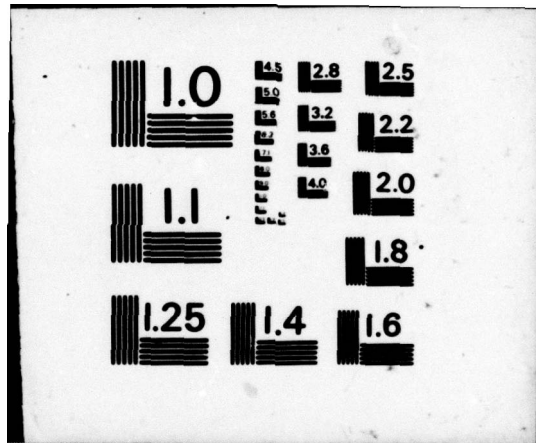
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10. Vocational Education in Rhode Island: A Background Report, Rhode Island Department of Education, Office of Planning and Management, Research, Planning and Evaluation, Providence, June 1974.
11. General Social and Economic Characteristics {1970 Census}, PC(1)-C4 RI, U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census, Washington, March 1972.
12. The Rhode Island Comprehensive Manpower Plan, Fiscal Year 1974, The Rhode Island Manpower Planning Council, Providence, undated manuscript.

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