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AUTHOR Garet, Michael S.
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INSTITUTION Management and Information System for Occupational Education, Winchester, Mass.
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ABSTRACT

The paper presents a speculative model of the growth and development of an occupational education program as it responds to changes in student interests and job market conditions. Informal discussions with the directors of several occupational schools in Massachusetts provided the base for the model. Intended as a tool for educational managers, to stimulate new thinking about policies and practices, the model can be described in precise mathematical terms, so that computer simulation can be used to test various policies and hypotheses. Not a detailed description of any single program, the discussion emphasizes aspects of all such programs important for an understanding of any single program. The model is experimented with, using different potential employment curves, and the response is shown for each of three possibilities. The study is framed in the system dynamics methodology of Jay W. Forrester, explained in the appendix, where a precise mathematical formalization of the assumptions discussed is given. (Author/AJ)

THE GROWTH OF AN OCCUPATIONAL EDUCATION PROGRAM

Michael Garet

March 1973

Management and Information System for Occupational Education
1017 Main Street
Winchester, Massachusetts 01890

THE GROWTH OF AN OCCUPATIONAL EDUCATION PROGRAM

Introduction

This short paper presents a speculative model of the growth and development of an occupational education program as it responds to changes in student interests and job market conditions. The model is based upon informal discussions with the directors of several occupational education schools in Massachusetts.* The model is intended as a tool, like a chart, diagram, or piece of scientific apparatus, to be used by educational managers to stimulate new thinking about policies and practices.

*Greater Lawrence Regional Vocational Technical School
Lawrence, Massachusetts

Newton Technical High School
Newtonville, Massachusetts

Northeast Metropolitan Regional Vocational School
Wakefield, Massachusetts

Quincy Public Schools
Quincy, Massachusetts

I. The Growth and Development of an Occupational Education Program

In Massachusetts, cccupational education schools are generally large, city or region-wide complexes offering as many as twenty different kinds of programs. The programs require two to four years to complete, and they enroll students age fifteen to eighteen. Students must apply for places in occupational programs, and for many programs the competition is keen. The annual per student expenditure for occupational education students is significantly higher than for either college-preparatory or general high school students.

Historically, occupational education has not been given priority by education professionals. Its growth has been until recently accomplished through the influence of business leaders on state and local government -- a town, in urging firms to locate nearby, would often agree to provide the vocational training required by a new firm, in return for expected revenues and other benefits derived from economic expansion. Recently, as jobs for the unskilled have disappeared and interest in using education as a social policy instrument to alleviate poverty has grown, occupational education has become a primary concern of professional educators. In addition, state lawmakers see occupational education as an attractive alternative to further proliferation of colleges and universities.

Two issues continually reappear in discussing occupational education. First, the number of students seeking entrance to a program is sometimes much greater and sometimes much smaller than the available space; and second, the number of graduates in a job-skill area often does not correspond to the number of new employees desired by the appropriate local industry.

For example, there is a large textile-training program in one school, built just before the exodus of the local textile firms to the South -- and now almost no one applies, leaving the program vacant. In a second school, there are far more applicants to the auto-mechanics program than places for students. In a third school, there are empty places in a machinist program, even though there are many unfilled machinist jobs available locally.

The model discussed below indicates how the decisions of three groups -- youth, business, and occupational education program managers -- can interact to produce the kinds of problems mentioned. For each of these three groups, the model explains the manner in which decisions are made in reaction to certain kinds of information and influence. The model can be described in precise mathematical terms, so that computer simulation can be used to test various policies and hypotheses.

The model describes a "typical" occupational program at a single school. The typical program might represent, for example, woodworking, practical nursing, or accounting. The discussion is not a detailed description of any single program; it is instead a model which emphasizes aspects of all such programs important for an understanding of any single program.

II. Local Business

To the typical occupational education program corresponds a number of local businesses or service agencies which employ program graduates. In this section, we will discuss factors which influence the demand for graduates. While it is of course true that some graduates of Massachusetts occupational education programs leave the state or region to find jobs elsewhere, programs generally place graduates locally. We will thus restrict our discussion to factors influencing the local demand for graduates, taking "local" to mean primarily the state of Massachusetts. Demand must be considered separately for two classes of occupations -- production occupations (mining, manufacturing, construction) and social service occupations (health, education, sanitation).

Local business of the production variety faces a growth trend, based upon national economic health, local economic features (such as declining resource availability, rising land prices), and social or political factors. Local enterprises follow the trend, growing a bit faster than the trend when many skilled employees are available and growing more slowly or not at all when employees are unavailable. If skilled employees are unavailable when trend is positive, local business will simply fail to develop, even if skilled employees should become available at a later time -- because business will move from the area to take advantage of opportunity elsewhere.

Production firms hire graduates both to replace employees leaving the firm and to increase the size of the firm. The number of new employees demanded by local production firms is thus a function of the present size of the local business and the growth trend.

Local "social service" enterprises attempt to meet certain local service demands. If sufficient skilled employees are unavailable, these service demands persist until employees do become available -- social service agencies (such as schools or law enforcement) cannot move elsewhere. The number of new employees desired by a local service agency is a function of the difference between the size of the agency and the size necessary to meet local service demands.

There is thus a characteristic distinction between the two forms of employment opportunity. In the production sector, local job opportunities which are not filled eventually disappear, as firms move or the industry declines. In the social services, opportunities remain until service needs are met.

III. Youth

Youth may choose to enter an occupational education program on the basis of parental pressure, peer pressure, interest, employment expectations, whim, and many other influences. We can distinguish two competing kinds of pressures -- those which tend to make the occupational choices of youth more dependent on future employment possibilities, and those which make this dependence less strong. Some occupations (such as auto mechanic) are interesting for a large number of reasons, many totally unrelated to job opportunity. Interest in other occupations may depend completely upon whether jobs are available.

In certain communities, a few occupations may be seen as unusually desirable because of ethnic influences, while other jobs may be considered totally unacceptable, regardless of employment opportunity.

To the extent that youth decisions to enter a particular program are made on the basis of job opportunity, two factors are crucial: the extent to which opportunity appears to be growing or declining, and the percentage of program graduates able to secure jobs. If opportunity is growing and a high proportion of skilled youth find jobs, interest in the new program grows; if opportunity is declining and a low fraction of program graduates find employment, interest declines.

IV. Program Managers

Program managers must weigh a large number of factors in deciding whether or not to increase the size of a program. Perceived need for additional skilled employees, availability of resources, attractiveness of competing programs, student interest, and political realities all play a role. We can again distinguish two competing kinds of pressures -- those which tend to make decisions more sensitive to employment conditions and those which make decisions less sensitive to job possibilities.

Decisions made by program managers are necessarily incremental -- managers can seek to enlarge or slowly curtail a program, but can rarely make an enormous alteration in a single act.

V. Parameters

A number of parameter values must be specified and, in particular, a growth trend (for production occupations) or desired employment (for service occupations) postulated in order to analyze model behavior.

For demonstration purposes, the following parameters and initial conditions have been chosen. They represent no specific program; obtaining satisfactory parameters for an actual program would require the development of an appropriate empirical research methodology.

initial enrollment	180 men & women
initial employment	400 men & women
initial employment opportunity	40 jobs/yr.
initial physical plant capacity	180 places
initial desirability of program perceived by youth	50 applicants/yr.
initial desired change in enrollment capacity	0 places/yr.
duration of program	4 years
dropout rate	20%
retirement fraction (for business employees)	10%/yr.

Under these conditions, the system is in equilibrium: 50 new students enroll in the program per year, 40 graduate, and all 40 are hired. Additional details are given in the Appendix.

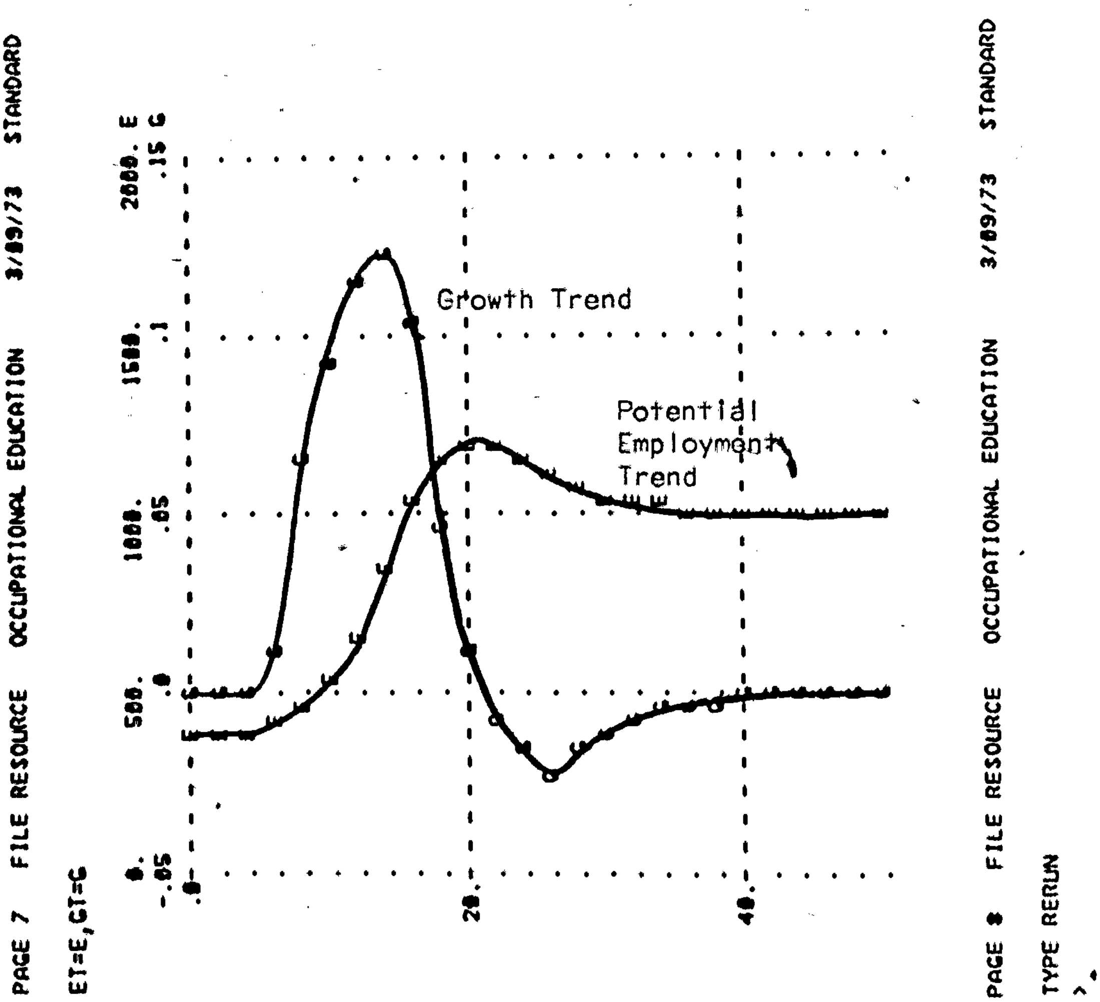
To obtain the growth trend for business, we have hypothesized a "potential employment curve." The curve represents the size our "typical" class of local business could attain, given the overall economic, political, and social conditions of the region under circumstances of unlimited skilled labor availability. The rate of change of this "potential employment curve" over time gives the growth trend.

Of course, obtaining a "true" potential employment curve for any actual class of business would be an impossible task. However, we are more interested in analyzing the capability of the occupational education system to respond to alternative possible futures than we are in forecasting which future in particular will come to be. Thus we should experiment with the model using different potential employment curves, to see how it responds to each possibility. For the basic model, the potential employment curve and growth trend are as given in the graph below, for a fifty year period.*

*The curves in the graphs which follow are computer plots showing the behavior of selected system variables as generated through time by the simulation model. The horizontal axis is a time scale, starting with the present time as zero (0) and running for the next fifty years. In the "Potential Employment and Growth Trend" plot, the following plotting symbols are used; G = Growth Trend (measured in percent growth/year), E = Employment Trend (jobs). In the remaining plots, E = Employment (jobs), F = Fraction of Graduates Unemployed (percent), O = Employment Opportunity (jobs/year), N = Enrollment (students), Y = Youth Desiring to Enroll (applicants/year), X = Physical Plant (places).

The vertical scales at the left of each plot are marked at the top with the symbol to which they apply. For example, in the following plot, the Employment Trend (E) runs from 0 to 2000 jobs, and the Growth Trend (G) runs from -.05 to +.15 (-5 to +15 percent/year).

POTENTIAL EMPLOYMENT AND GROWTH TREND



VI. Model Behavior

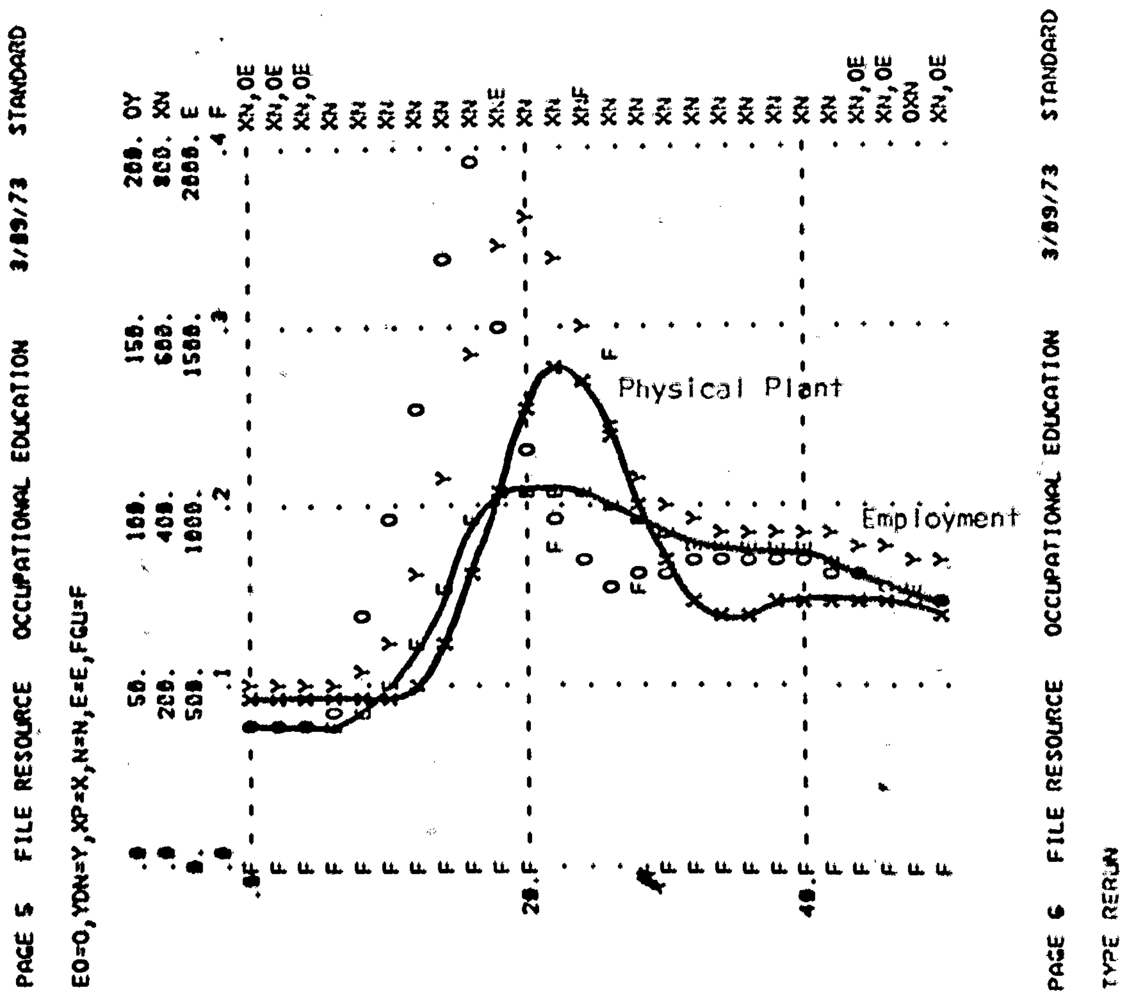
A precise mathematical formalization of the assumptions we have discussed is given in the Appendix. Using this formalization, it is possible to test various assumptions and policy alternatives by simulating the model on a computer.

A graph depicting the time series of several important variables in the basic model is shown below. The time period is 50 years, and there is an initial pool of 800 skilled persons available, either employed by declining industries or brought to the area by the growing business, to support the first few years of business expansion.

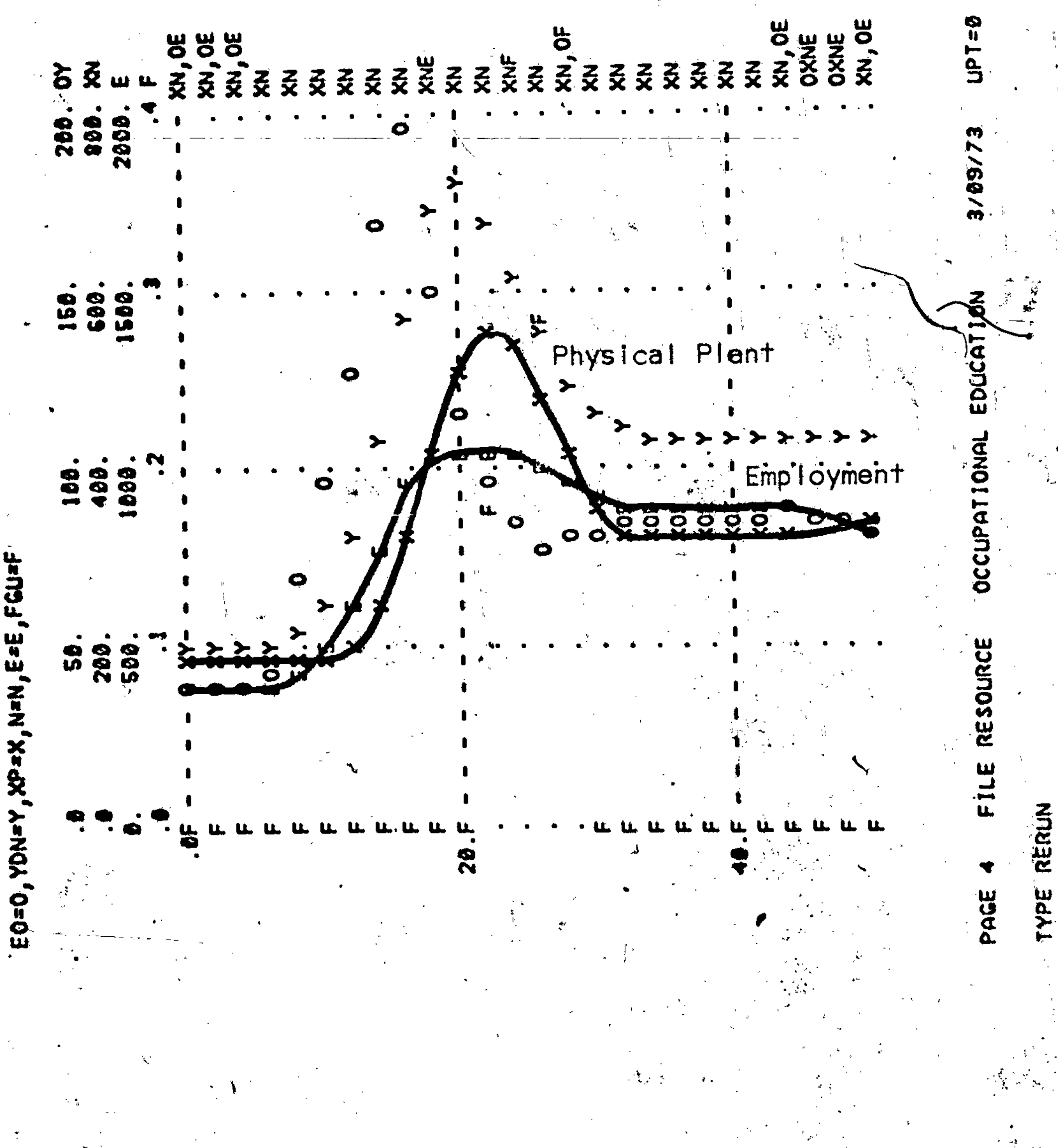
As can be seen, the maximum size achieved by business is about 1100, or about 100 less than the "potential" maximum of 1200 -- due to a shortage of skilled employees. When industrial growth turns to decline, employment opportunity drops to mere replacement value, many program graduates cannot find work, and both the number of youth applicants and the size of the program decline. Because program capacity is not easily discarded (due to teacher tenure, specialized equipment, etc.), excess capacity remains for a number of years. Unfortunately, the decline in program size continues until the number of graduates dips below the number required to maintain the present size of industry, and industrial decline begins.

In the next model run, unemployment of graduates is assumed to have no effect on either youth or program manager decisions. In this run, because unemployment has no effect on decisions, the decline of the program in the years following the turning point in industrial expansion is not nearly so great as in the basic run; consequently a sufficient number of youth graduate each year to maintain a stable industrial size of 900, nearly the potential maximum of 1000.

THE BASIC MODEL



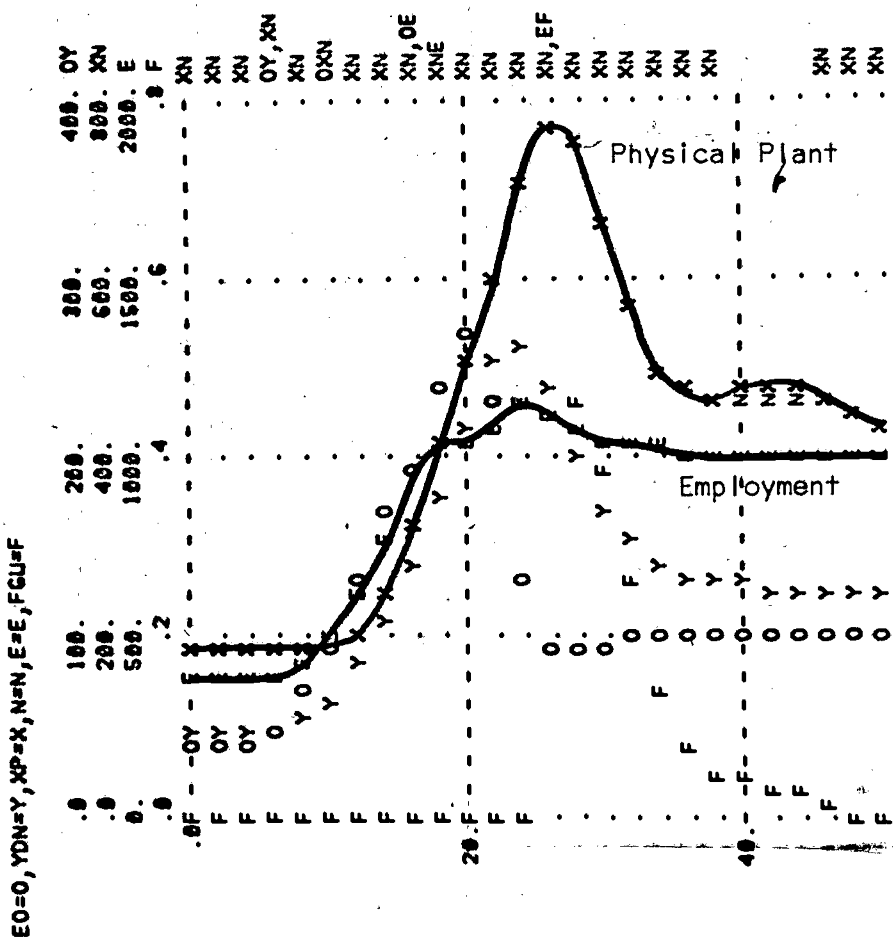
UNEMPLOYMENT ASSUMED TO HAVE NO EFFECT ON DECISIONS



The final run demonstrates a social service occupation, with unemployment again assumed to have no effect on decisions. Because social service agencies cannot move from the local area when the supply of skilled labor is low, demand for labor continues until it is met. Consequently, a stable agency size of 1000 is reached, equal to the maximum potential. However, there is considerable over-investment and oscillation in program physical plant.

As is clear from these three runs delay in program acquisition of physical plant causes both overshoot and oscillations in program capacity. These could be corrected by accurate anticipation of future industrial trends on the part of program managers, although such anticipation may be costly, impossible, or both.

A SOCIAL SERVICE OCCUPATION



PAGE 7 FILE RESOURCE OCCUPATIONAL EDUCATION 3/09/73 UPT=0 SSO

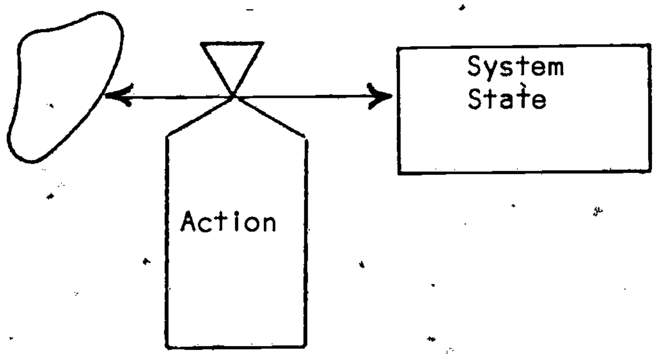
TYPE RERUN

APPENDIX

The study in the text is framed in the system dynamics methodology of Jay W. Forrester.* Forrester stresses the importance of viewing social organizations as complex, multi-loop feedback systems - systems involving multiple chains of cause and effect.

A social system is a structure of interacting decisions and actions. Over time, the consequences of actions accumulate, perhaps changing the condition or "state" of the system.

It is often useful to represent the accumulated results of continuing system actions as "stocks" or "levels" and to represent the action themselves as "flows" or "rates". This idea is shown symbolically below:



An action is a rate of flow which changes a system state or level.

In general, actions affect either flows of objects or flows of information. Objects--such as automobiles or construction materials--are physically conserved. If an object disappears from one location, it must appear somewhere else. Information--such as knowledge of food prices or

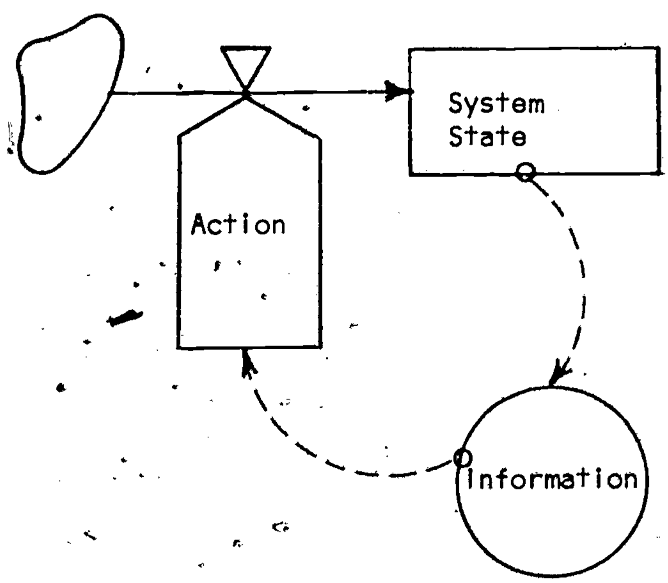
*Jay W. Forrester, Industrial Dynamics, MIT Press, Cambridge, Massachusetts, 1961.

*Jay W. Forrester, Urban Dynamics, MIT Press, Cambridge, Massachusetts, 1969.

*Jay W. Forrester, World Dynamics, Wright-Allen Press, Cambridge, Mass., 1971.

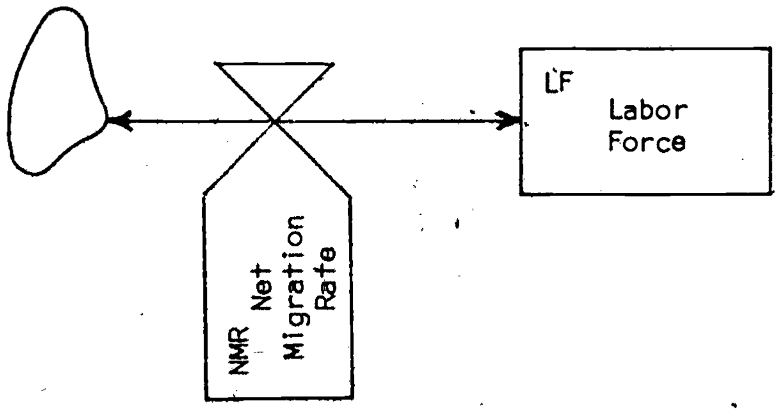
consciousness of poverty is symbolic. Many people can share the same knowledge; hence, information is not conserved.

Social action is based upon information about the system. Information may involve simple reflex or sophisticated data-gathering technologies, and it may include knowledge of the marketplace, political belief and religious orientation.



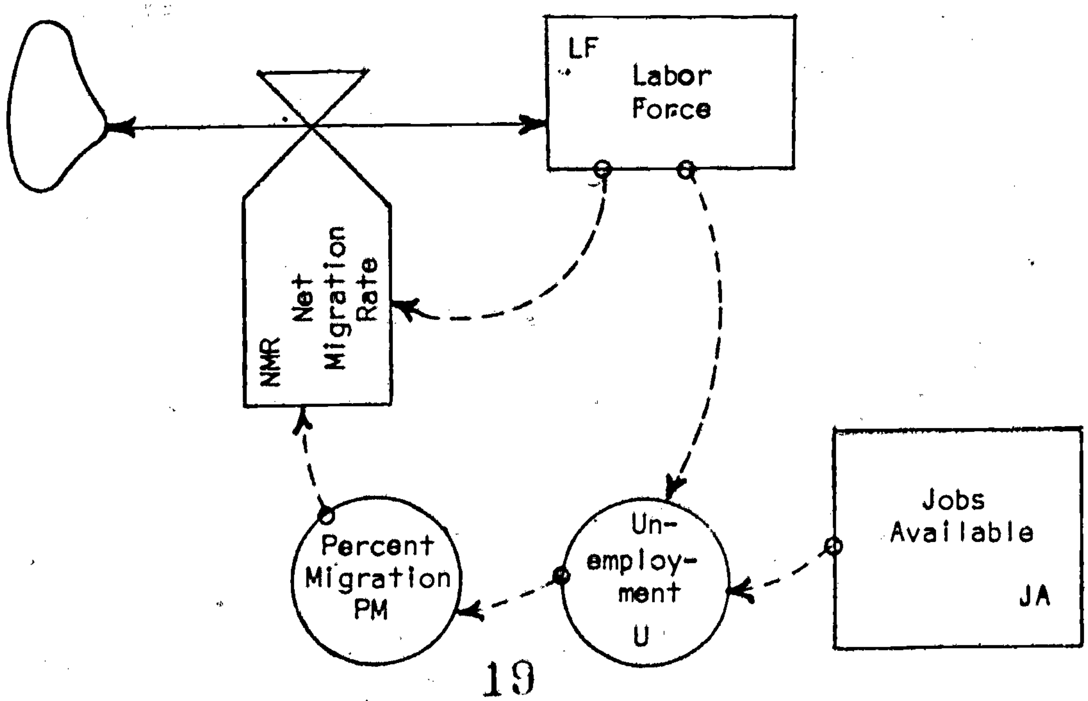
For example, the schools in a community can be viewed as a system. System actions or rates includes students enrolling, learning, dropping out, or graduating; contractors constructing physical facilities; teachers changing the curriculum; and administrators debating the demands of students, parents, city, state and federal government. System states or levels include: the number of students enrolled; the physical plant capacity; the nature of the curriculum; the relative political influence of various interest groups.

As another example, we will consider in detail a very simple model of regional employment and unemployment. The model is represented in symbolic form below:

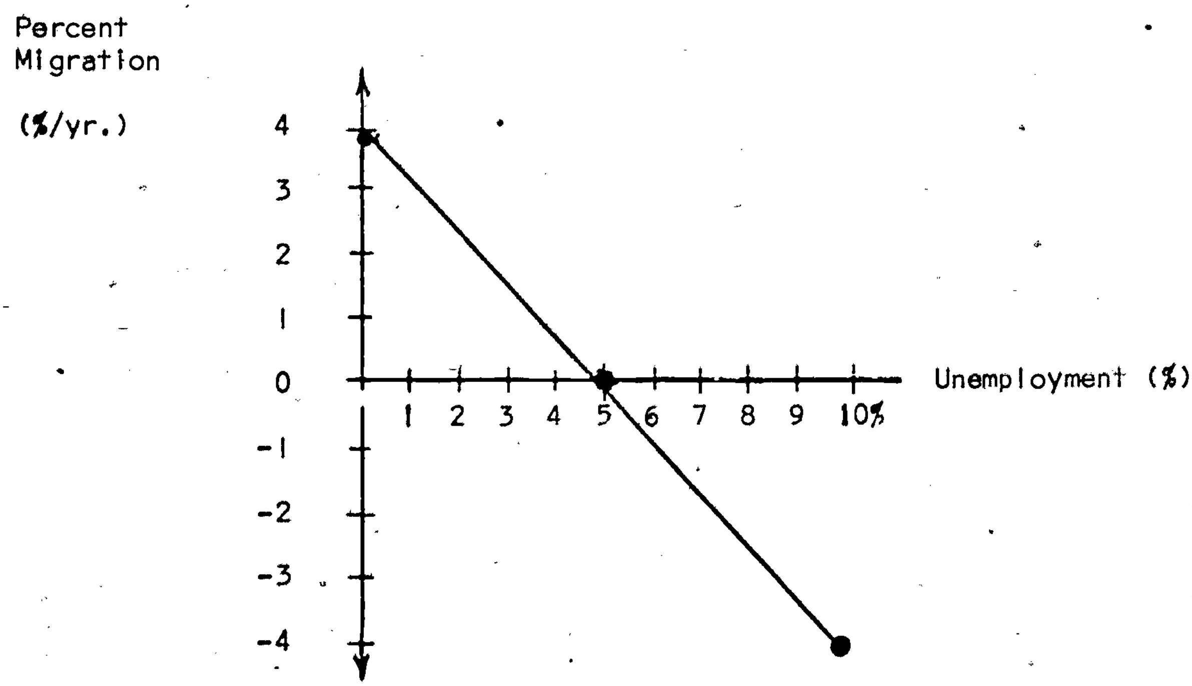


The size of the regional Labor Force (LF) is a system level which is influenced by the Net Migration Rate into the region. When migration is positive, there is a net inflow, and the Labor Force increases; when NMR is negative, there is a net outflow, and LF decreases.

The diagram below represents the highly simplified assumption that the Net Migration Rate is determined solely by unemployment conditions in the region.



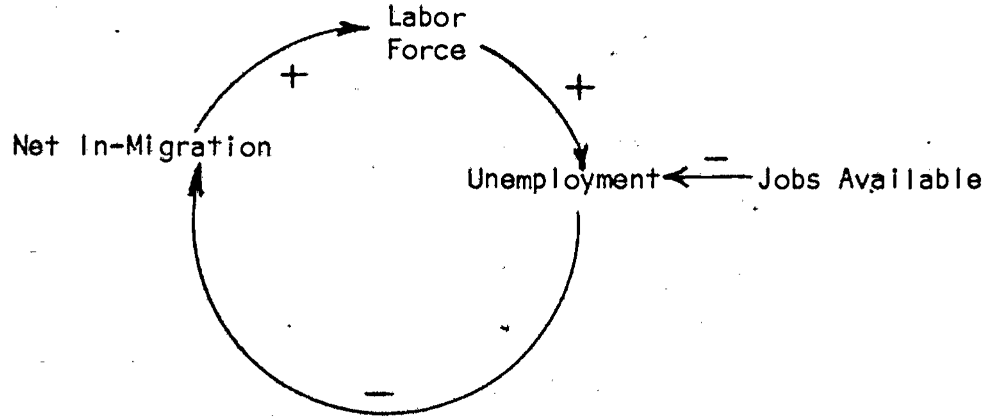
The difference between total Labor Force (LF) and Jobs Available (JA) gives the number of unemployed; and the ratio of unemployed to total Labor Force gives the Unemployment (in percent). Now, if we assume that Unemployment (U) determines the percent of the Labor Force which migrates in or out of our region per year, then the relationship between Unemployment and Percent Migration (PM) might take the following form:



Thus, if Unemployment is 5%, there is no net migration. If unemployment is 10%, there is a net outflow of 4% of the Labor Force per year; and if Unemployment is 0%, there is a net inflow of 4% of the Labor Force per year.

Finally, the Net Migration Rate is the product of the total Labor Force and the Percent Migration per year.

The simple model demonstrates a "feedback loop" structure which tends to preserve Unemployment at 5%, even if the Jobs Available should fluctuate. Any change in the number of Jobs Available is compensated by an increase or decrease in Net Migration. This feedback structure can be represented in a "causal loop diagram."



The positive and negative signs on the causal paths indicate direct and inverse relationships, respectively. For example, as the Labor Force increases, all else remaining equal, the Unemployment must ise; and as Unemployment rises, all else remaining equal, Net In-Migration must fall.

It is useful to express dynamic system models in mathematical terms, so that model behavior can be simulated on a computer. DYNAMO, a computer language written by Alexander Pugh, provides an elegant notation for system-dynamics models.*

*Alexander Pugh, Dynamo Users Manual, M.I.T. Press, Cambridge, Mass., 1970.

L	LF.J = LF.K + (DT)(NMR.JK)
N	LF = 100,000
R	NMR.KL = LF.K * PM.K
A	PM.K = TABLE (PMT, U.K, 0, .10, .05)
T	PMT = (.04/0/-.04)
A	U.K = (LF.K - JA.K)/LF.K
A	JA.K = TEST
C	TEST =

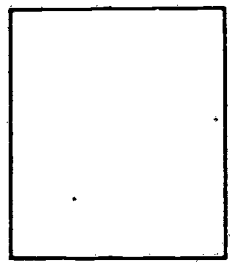
LF	LABOR FORCE (WORKERS)
NMR	NET MIGRATION RATE (WORKERS/YR)
PM	PERCENT MIGRATION (PERCENT/YR)
PMT	PM TABLE
U	UNEMPLOYMENT (PERCENT)
JA	JOBS AVAILABLE (WORKERS)
TEST	TEST INPUT

"L" indicates a level equation, "R" a rate equation, "A" an auxiliary equation, "N" an initial value for a level, and "T" a table used to express a functional relationship between two variables.*

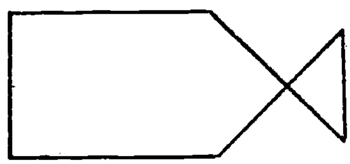
*Notice that the table expression PM.K = TABLE (PMT, U.K, 0, .10, .05) indicates that PM is a function of U given by the PMT table of values, and that the PMT table gives the values of PM as U varies from 0 to .10 in increments of .05. Thus when U = 0, PM = .04, when U = .05, PM = 0, and when U = .10, PM = -.04. Intermediate values are obtained by interpolation.

A flow diagram, causal loop diagram, and DYNAMO listing for the occupational education model are given below. The following glossary of symbols may be useful in interpreting the diagrams.

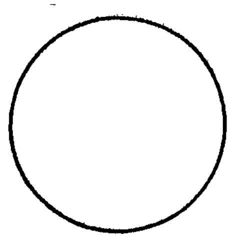
LEVEL



RATE

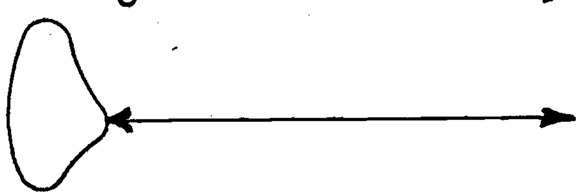


AUXILIARY

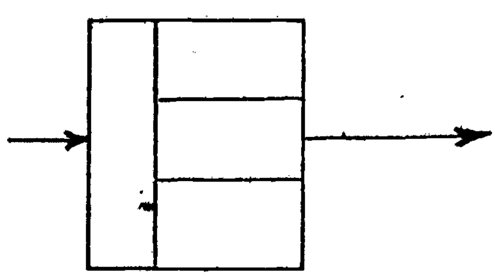


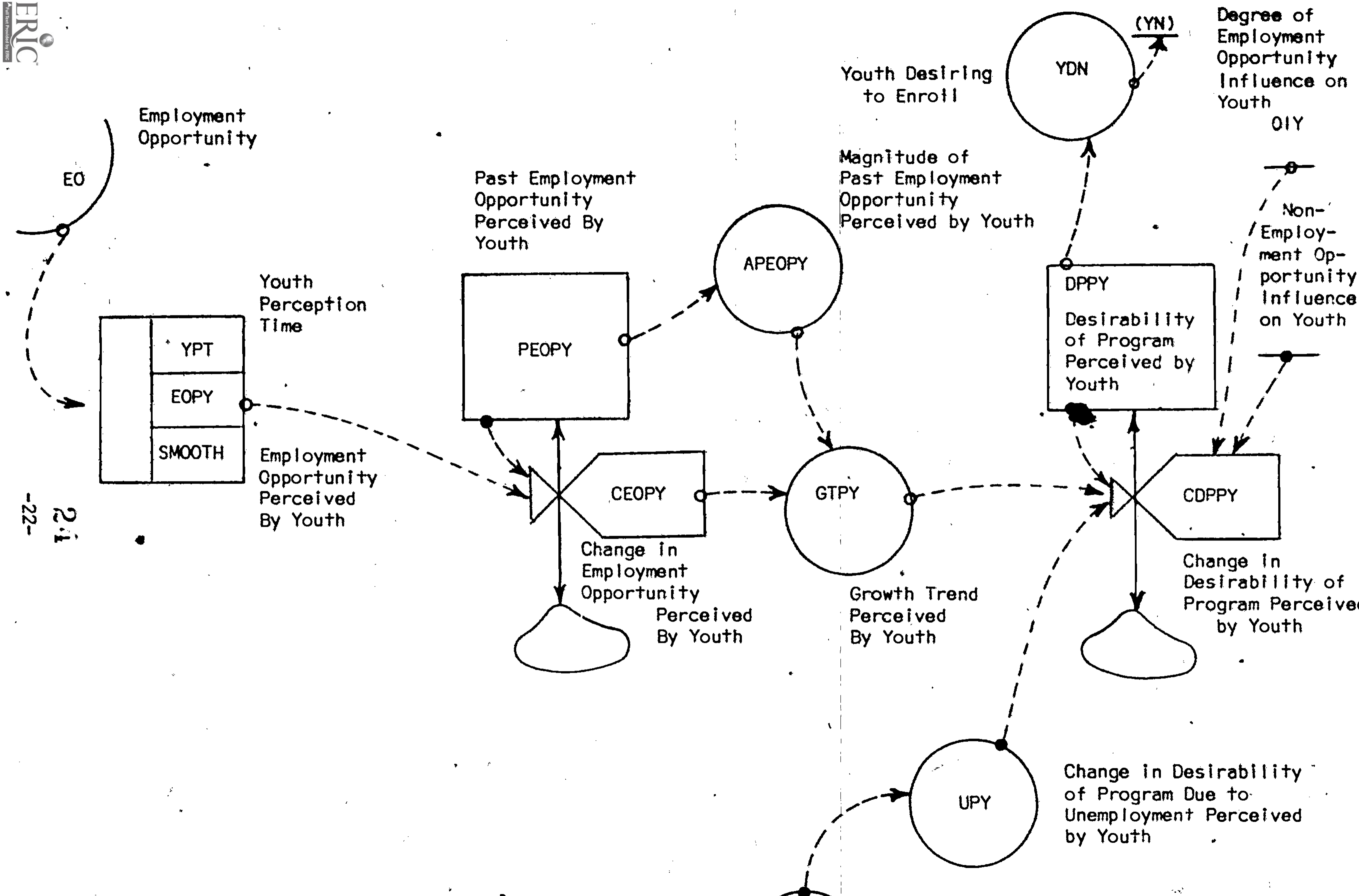
INFORMATION FLOW

CONSERVATIVE FLOW

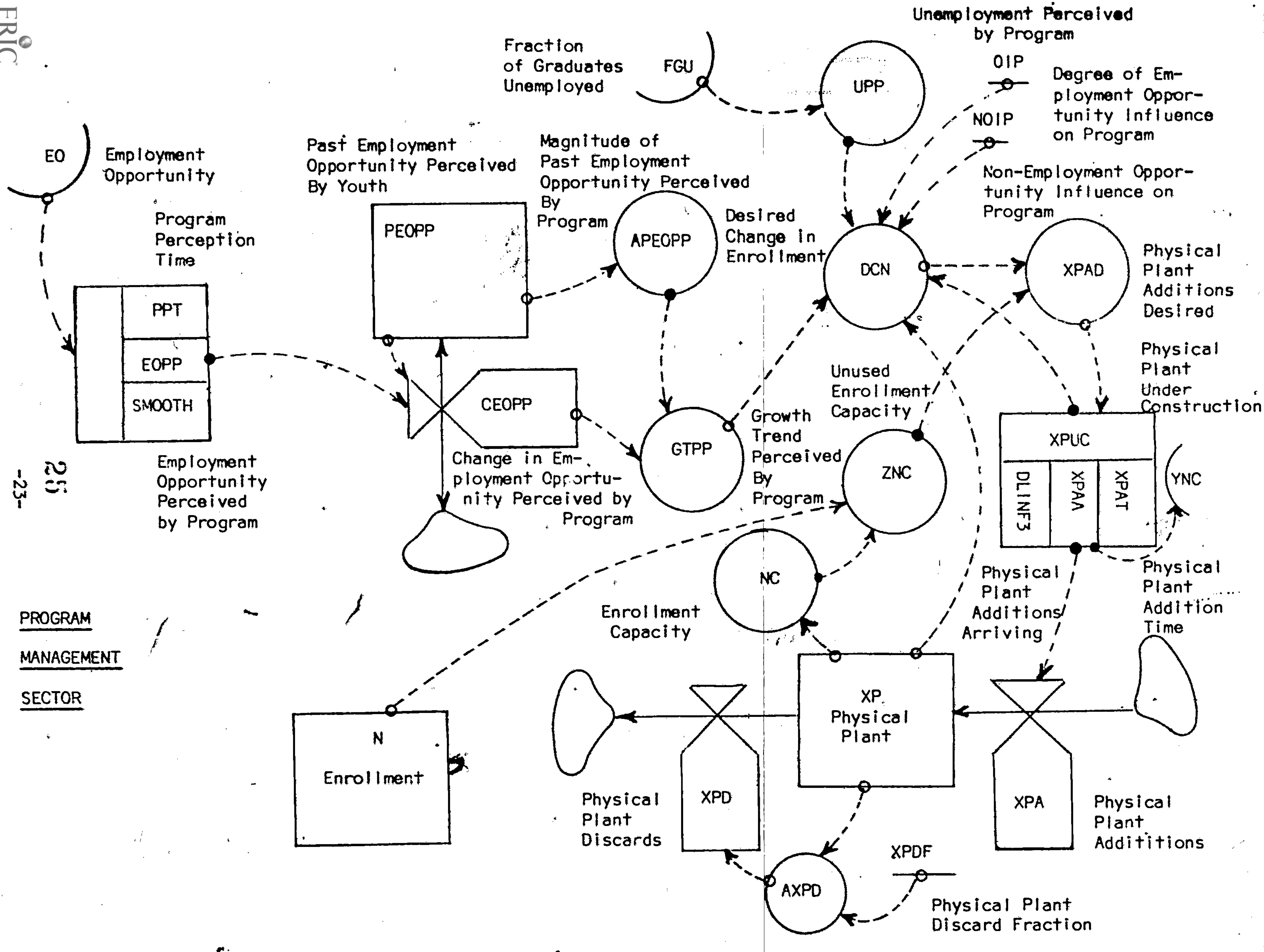


EXPONENTIAL TIME DELAY





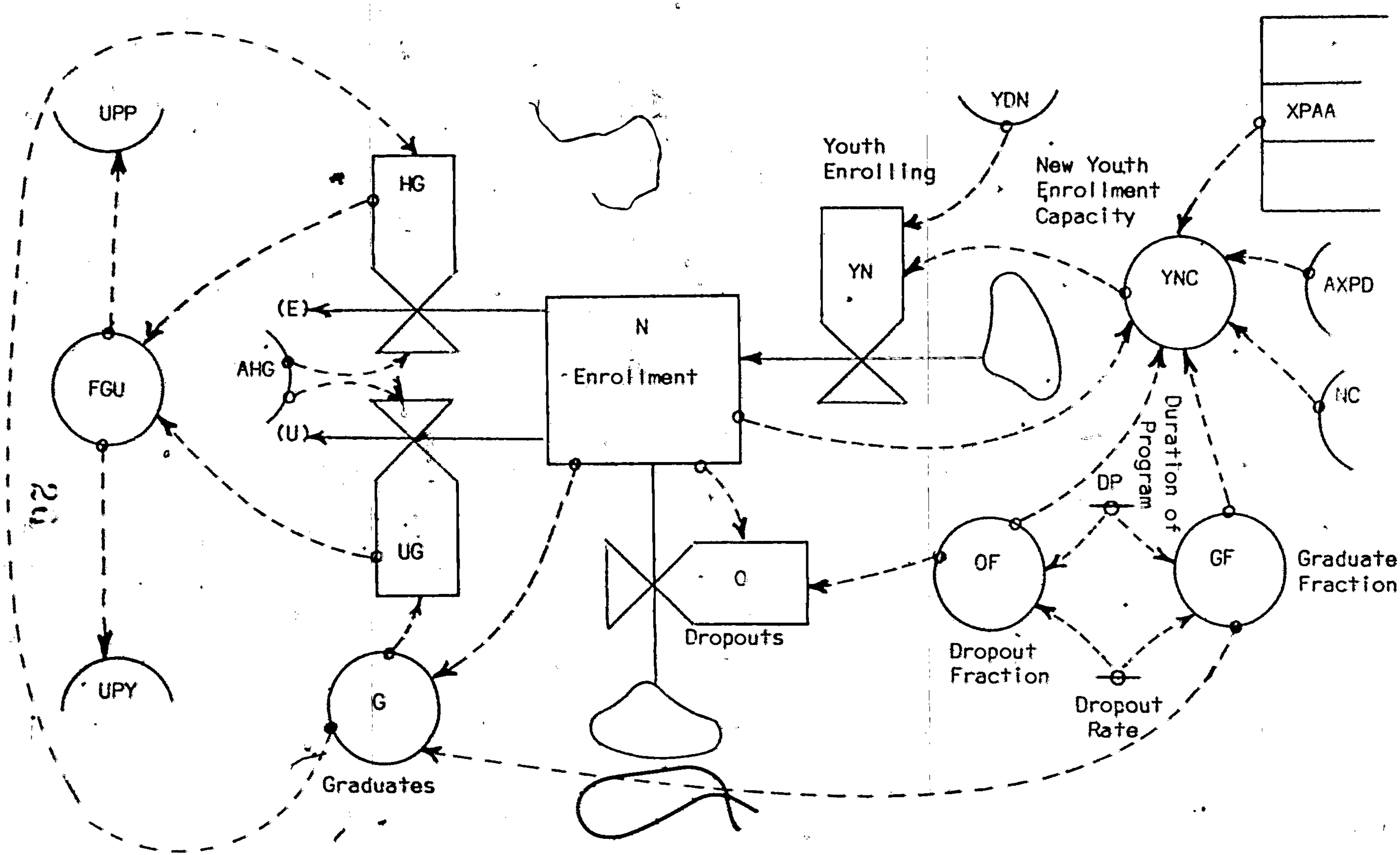
YOUTH SECTOR



PROGRAM

MANAGEMENT

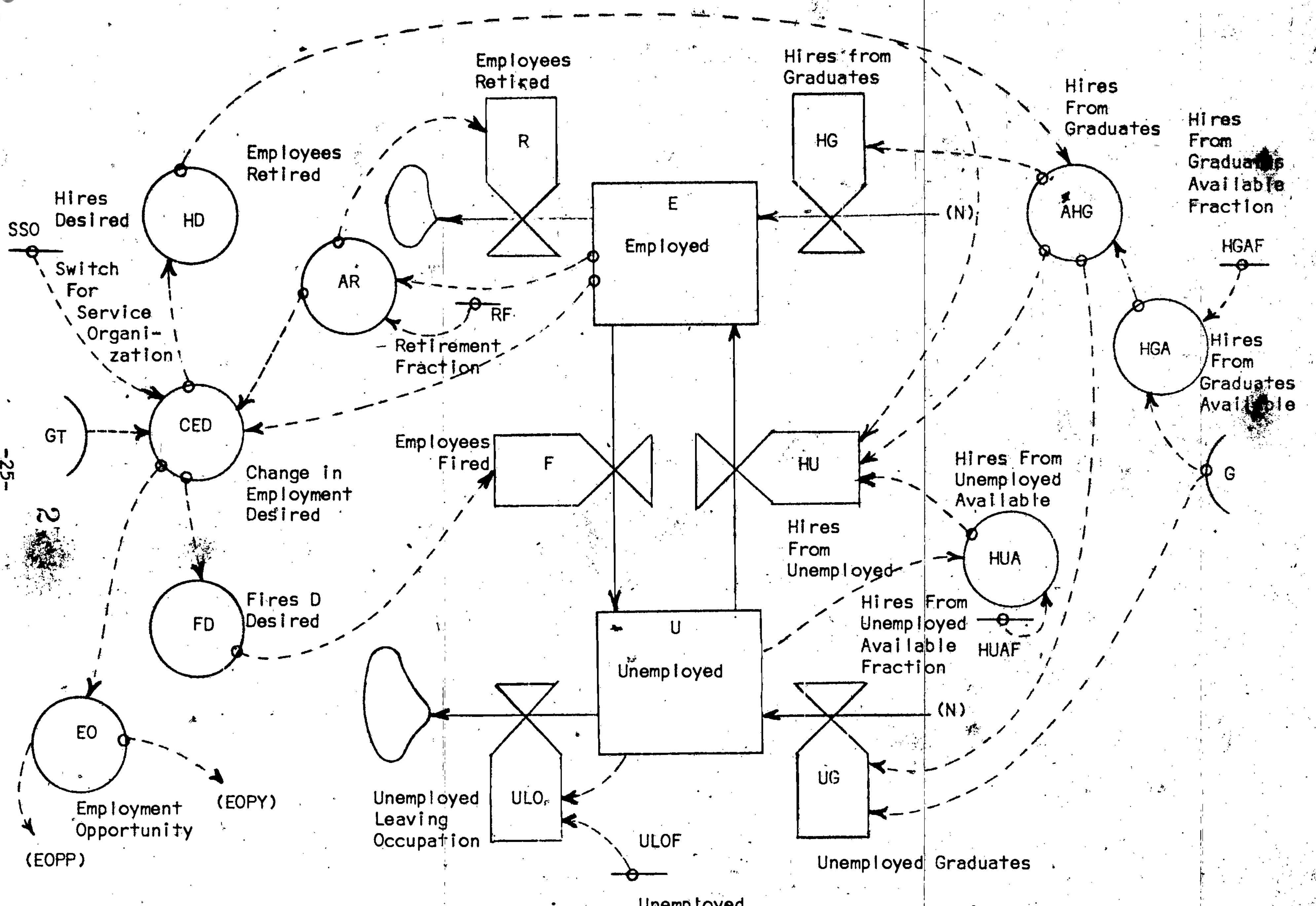
SECTOR



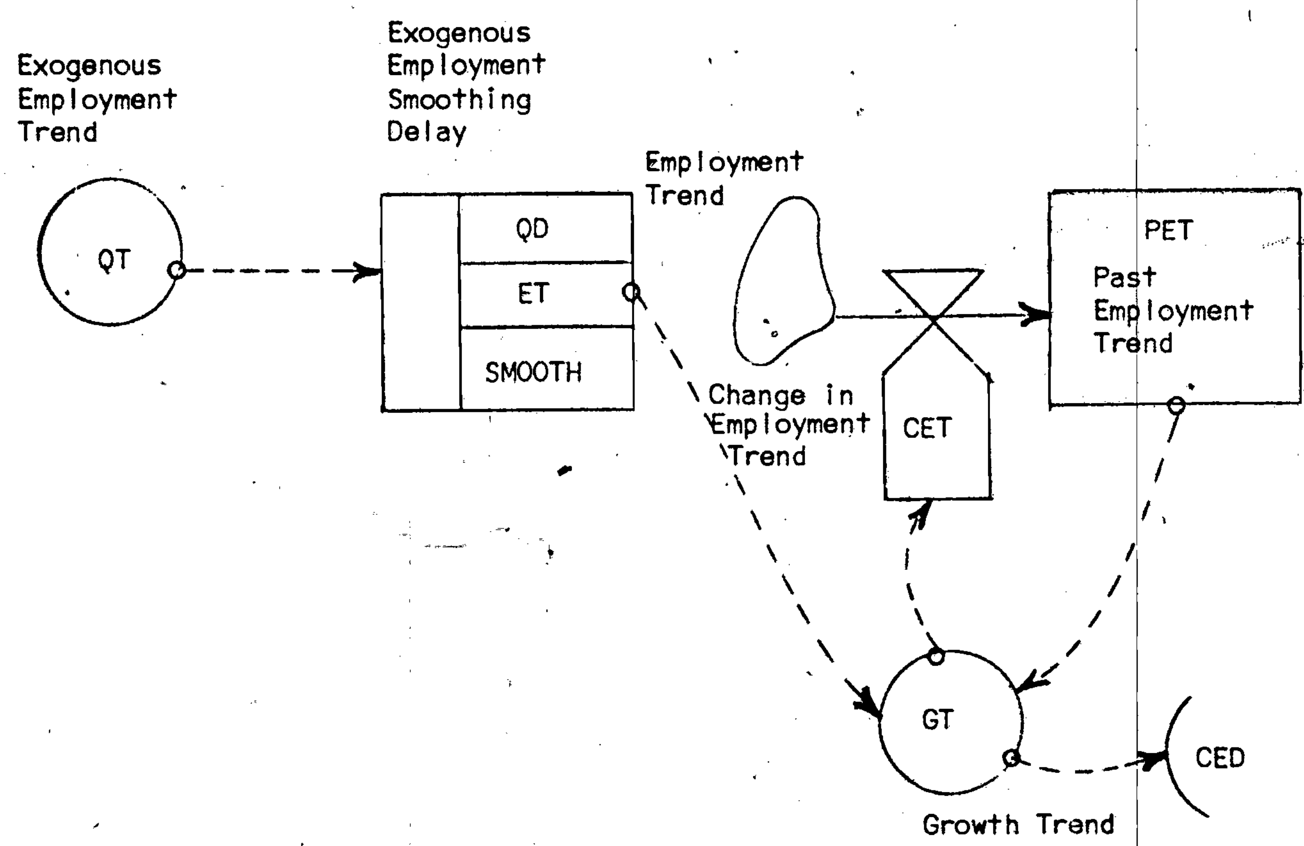
ENROLLMENT

SECTOR

26

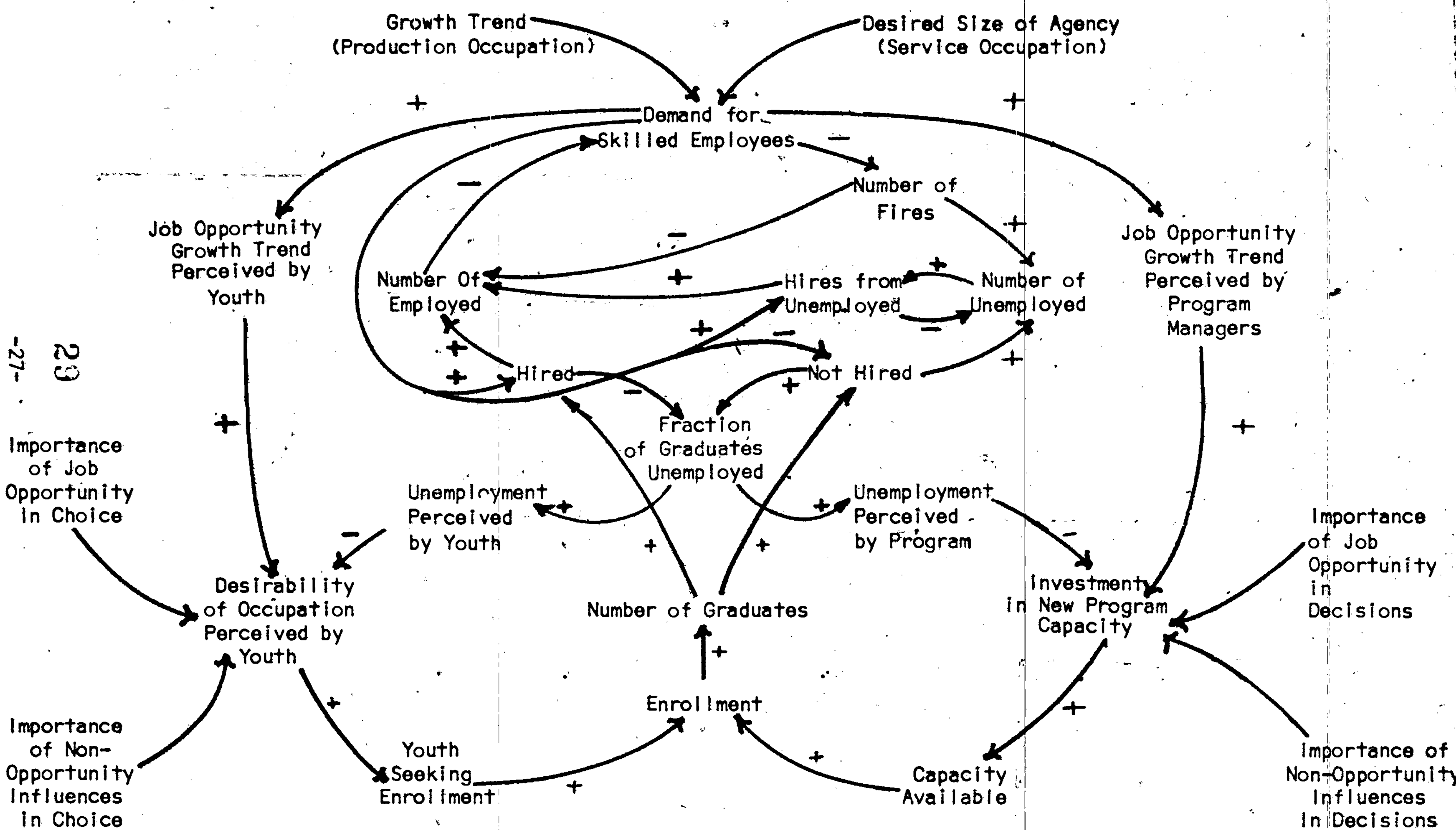


EMPLOYMENT SECTOR



EXOGENOUS
GROWTH TREND

CAUSAL LOOP DIAGRAM



```
EOPY.K=SMOOTH(EO.K,PTY)                                        1, A
EOPY=EO                                                        1.1, N
PTY=5                                                          1.2, C
    EOPY   - EMPLOYMENT OPPORTUNITY PERCEIVED BY YOUTH
               (JOBS/YR)
    EO     - EMPLOYMENT OPPORTUNITY (JOBS/YR)
    PTY    - PERCEPTION TIME OF YOUTH (YEARS)

PEOPY.K=PEOPY.J+(DT)(CEOPY.JK)                                 2, L
PEOPY=PEOPYN                                                   2.1, N
PEOPYN=40                                                      2.2, C
    PEOPY  - PAST EMPLOYMENT OPPORTUNITY PERCEIVED BY
               YOUTH (JOBS/YR)
    CEOPY  - CHANGE IN EMPLOYMENT OPPORTUNITY PERCEIVED
               BY YOUTH (JOBS/YR/YR)
    PEOPYN - INITIAL PAST EMPLOYMENT OPPORTUNITY
               PERCEIVED BY YOUTH (JOBS/YR)

CEOPY.KL=EOPY.K-PEOPY.K                                        3, R
    CEOPY  - CHANGE IN EMPLOYMENT OPPORTUNITY PERCEIVED
               BY YOUTH (JOBS/YR/YR)
    EOPY   - EMPLOYMENT OPPORTUNITY PERCEIVED BY YOUTH
               (JOBS/YR)
    PEOPY  - PAST EMPLOYMENT OPPORTUNITY PERCEIVED BY
               YOUTH (JOBS/YR)

GTPY.K=(EOPY.K-PEOPY.K)/APEOPY.K                               4, A
    GTPY   - GROWTH TREND PERCEIVED BY YOUTH (PERCENT/
               YR)
    EOPY   - EMPLOYMENT OPPORTUNITY PERCEIVED BY YOUTH
               (JOBS/YR)
    PEOPY  - PAST EMPLOYMENT OPPORTUNITY PERCEIVED BY
               YOUTH (JOBS/YR)
    APEOPY - ABSOLUTE VALUE OF PEOPY (JOBS/YR)

APEOPY.K=CLIP(PEOPY.K,-PEOPY.K,PEOPY.K,0)                      5, A
    APEOPY - ABSOLUTE VALUE OF PEOPY (JOBS/YR)
    PEOPY  - PAST EMPLOYMENT OPPORTUNITY PERCEIVED BY
               YOUTH (JOBS/YR)

DPPY.K=DPPY.J+(DT)(CDPPY.JK)                                   6, L
DPPY=DPPYN                                                     6.1, N
DPPYN=50                                                       6.2, C
    DPPY   - DESIRABILITY OF PROGRAM PERCEIVED BY YOUTH
               (APPLICANTS/YR)
    CDPPY  - CHANGE IN DESIRABILITY OF PROGRAM PERCEIVED
               BY YOUTH (APPLICANTS/YR/YR)
    DPPYN  - INITIAL DESIRABILITY OF PROGRAM PERCEIVED
               BY YOUTH (APPLICANTS/YR )
```

```
CDPPY.KL=((GTPY.K-UPY.K)(OIY)+NOIY)(DPPY.K)            7, R
OIY=1                                                    7.1, C
NOIY=0                                                   7.2, C
    CDPPY  - CHANGE IN DESIRABILITY OF PROGRAM PERCEIVED
               BY YOUTH (APPLICANTS/YR/YR)
    GTPY   - GROWTH TREND PERCEIVED BY YOUTH (PERCENT/
               YR)
    UPY    - UNEMPLOYMENT INFLUENCE ON YOUTH
               (DIMENSIONLESS)
    OIY    - EMPLOYMENT OPPORTUNITY INFLUENCE ON YOUTH
               (DIMENSIONLESS)
    NOIY   - NON EMPLOYMENT OPPORTUNITY INFLUENCES ON
               YOUTH (PERCENT/YR)
    DPPY   - DESIRABILITY OF PROGRAM PERCEIVED BY YOUTH
               (APPLICANTS/YR)

UPY.K=TABLE(UPYT,FGU.K,0,1,0.2)                          8, A
UPYT=0/0/.1/.2/.3/.4                                     8.1, T
    UPY    - UNEMPLOYMENT INFLUENCE ON YOUTH
               (DIMENSIONLESS)
    UPYT   - UNEMPLOYMENT INFLUENCE ON YOUTH TABLE
    FGU    - FRACTION OF GRADUATES UNEMPLOYED (PERCENT)
```

```
YDN.K=MAX(DPPY.K,0)                                       9, A
    YDN    - YOUTH DESIRING TO ENROLL (APPLICANTS/YR)
    DPPY   - DESIRABILITY OF PROGRAM PERCEIVED BY YOUTH
               (APPLICANTS/YR)

EOPP.K=SMOOTH(EO.K,PTP)                                   10, A
EOPP=EOPPN                                                10.1, N
EOPPN=EO                                                  10.2, N
PTP=2                                                     10.3, C
    EOPP   - EMPLOYMENT OPPORTUNITY PERCEIVED BY PROGRAM
               (JOBS/YR)
    EO     - EMPLOYMENT OPPORTUNITY (JOBS/YR)
    PTP    - PERCEPTION TIME OF THE PROGRAM (YEARS)

PEOPP.K=PEOPP.J+(DT)(CEOPP.JK)                            11, L
PEOPP=PEOPPN                                              11.1, N
PEOPPN=40                                                 11.2, C
    PEOPP  - PAST EMPLOYMENT OPPORTUNITY PERCEIVED BY
               PROGRAM (JOBS/YR)
    CEOPP  - CHANGE IN EMPLOYMENT OPPORTUNITY PERCEIVED
               BY PROGRAM (JOBS/YR/YR )
    PEOPPN - INITIAL PAST EMPLOYMENT OPPORTUNITY
               PERCEIVED BY PROGRAM (JOBS/Y R)

CEOPP.KL=EOPP.K-PEOPP.K                                   12, R
    CEOPP  - CHANGE IN EMPLOYMENT OPPORTUNITY PERCEIVED
               BY PROGRAM (JOBS/YR/YR )
    EOPP   - EMPLOYMENT OPPORTUNITY PERCEIVED BY PROGRAM
               (JOBS/YR)
    PEOPP  - PAST EMPLOYMENT OPPORTUNITY PERCEIVED BY
               PROGRAM (JOBS/YR)

GTPP.K=(EOPP.K-PEOPP.K)/APEOPP.K                          13, A
    GTPP   - GROWTH TREND PERCEIVED BY PROGRAM (PERCENT/
               YR)
    EOPP   - EMPLOYMENT OPPORTUNITY PERCEIVED BY PROGRAM
               (JOBS/YR)
    PEOPP  - PAST EMPLOYMENT OPPORTUNITY PERCEIVED BY
               PROGRAM (JOBS/YR)
    APEOPP - ABSOLUTE VALUE OF PEOPP (JOBS/YR)

APEOPP.K=CLIP(PEOPP.K,-PEOPP.K,PEOPP.K,0)                 14, A
    APEOPP - ABSOLUTE VALUE OF PEOPP (JOBS/YR)
    PEOPP  - PAST EMPLOYMENT OPPORTUNITY PERCEIVED BY
               PROGRAM (JOBS/YR)
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DCN.K=((GTPP.K-UPP.K)(OIP)+NOIP)(XP.K+XPUC.K)             15, A
OIP=1                                                     15.1, C
NOIP=0                                                    15.2, C
    DCN    - DESIRED CHANGE IN ENROLLMENT (PLACES/YR)
    GTPP   - GROWTH TREND PERCEIVED BY PROGRAM (PERCENT/
               YR)
    UPP    - UNEMPLOYMENT INFLUENCE ON PROGRAM
               (DIMENSIONLESS)
    OIP    - EMPLOYMENT OPPORTUNITY INFLUENCE ON PROGRAM
               (DIMENSIONLESS)
    NOIP   - NON EMPLOYMENT OPPORTUNITY INFLUENCE ON
               PROGRAM (PERCENT/YR)
    XP     - PHYSICAL PLANT (PLACES)
    XPUC   - PHYSICAL PLANT UNDER CONSTRUCTION (PLACES)

UPP.K=TABLE(UPPT,FGU.K,0,1,0.2)                           16, A
UPPT=0/0/.1/.2/.3/.4                                      16.1, T
    UPP    - UNEMPLOYMENT INFLUENCE ON PROGRAM
               (DIMENSIONLESS)
    UPPT   - UNEMPLOYMENT INFLUENCE ON PROGRAM TABLE
    FGU    - FRACTION OF GRADUATES UNEMPLOYED (PERCENT)

XP.K=XP.J+(DT)(XPA.JK-XPD.JK)                             17, L
XP=XPN                                                    17.1, N
XPN=180                                                   17.2, C
    XP     - PHYSICAL PLANT (PLACES)
    XPA    - PHYSICAL PLANT ADDITONS (PLACES/YR)
    XPD    - PHYSICAL PLANT DISCARDS (PLACES/YR)
    XPN    - INITIAL PHYSICAL PLANT (PLACES)

XPAD.K=MAX(DCN.K-ZNC.K+(XP.K)(XPDF),0)                    18, A
    XPAD   - PHYSICAL PLANT ADDITIONS DESIRED (PLACES/
               YR)
    DCN    - DESIRED CHANGE IN ENROLLMENT (PLACES/YR)
    ZNC    - UNUSED ENROLLMENT CAPACITY (PLACES)
    XP     - PHYSICAL PLANT (PLACES)
    XPDF   - PHYSICAL PLANT DISCARD FRACTION (1/YR)

XPAA.K=DLINF3(XPAD.K,XPAT)                                19, A
    XPAA   - PHYSICAL PLANT ADDITIONS ARRIVING (PLACES/
               YR)
    XPAD   - PHYSICAL PLANT ADDITIONS DESIRED (PLACES/
               YR)
    XPAT   - PHYSICAL PLANT ADDITION TIME (YEARS)

XPA.KL=XPAA.K                                             20, R
XPAT=5                                                    20.1, C
    XPA    - PHYSICAL PLANT ADDITONS (PLACES/YR)
    XPAA   - PHYSICAL PLANT ADDITIONS ARRIVING (PLACES/
               YR)
    XPAT   - PHYSICAL PLANT ADDITION TIME (YEARS)
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XPUC.K=XPUC.J+(DT)(CXPUC.JK)                                21, L
XPUC=XPUCN                                                  21.1, N
XPUCN=0                                                     21.2, C
    XPUC    - PHYSICAL PLANT UNDER CONSTRUCTION (PLACES)
    CXPUC   - CHANGE IN PHYSICAL PLANT UNDER CONSTRUCTION
                (PLACES/YR)
    XPUCN   - INITIAL PHYSICAL PLANT UNDER CONSTRUCTION
                (PLACES)

CXPUC.KL=XPAD.K-XPAA.K                                      22, R
    CXPUC   - CHANGE IN PHYSICAL PLANT UNDER CONSTRUCTION
                (PLACES/YR)
    XPAD    - PHYSICAL PLANT ADDITIONS DESIRED (PLACES/
                YR)
    XPAA    - PHYSICAL PLANT ADDITIONS ARRIVING (PLACES/
                YR)

XPD.KL=(XP.K)(XPDF)                                         23, R
XPDF=0.1                                                    23.1, C
    XPD     - PHYSICAL PLANT DISCARDS (PLACES/YR)
    XP      - PHYSICAL PLANT (PLACES)
    XPDF    - PHYSICAL PLANT DISCARD FRACTION (1/YR)

NC.K=XP.K                                                   24, A
    NC      - ENROLLMENT CAPACITY (PLACES)
    XP      - PHYSICAL PLANT (PLACES)
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ZNC.K=NC.K-N.K                                          25, A
    ZNC    - UNUSED ENROLLMENT CAPACITY (PLACES)
    NC     - ENROLLMENT CAPACITY (PLACES)
    N      - ENROLLMENT (STUDENTS)

N.K=N.J+(DT)(YN.JK-HG.JK-UG.JK-O.JK)                    26, L
N=NN                                                    26.1, N
NN=180                                                  26.2, C
    N      - ENROLLMENT (STUDENTS)
    YN     - YOUTH ENROLLING (STUDENTS/YR)
    HG     - HIRES FROM GRADUATES (WORKERS/YR)
    UG     - UNEMPLOYED FROM GRADUATES (PERSONS/YR)
    O      - DROPOUTS (STUDENTS/YR)
    NN     - INITIAL ENROLLMENT (STUDENTS)

YN.KL=MIN(YDN.K,YNC.K)                                  27, R
    YN     - YOUTH ENROLLING (STUDENTS/YR)
    YDN    - YOUTH DESIRING TO ENROLL (APPLICANTS/YR)
    YNC    - YOUTH ENROLLMENT CAPACITY (STUDENTS/YR)

YNC.K=NC.K-(N.K)(1-GF-OF)+XPAA.K-XP.K*XPDF              28, A
GF=(1-OR)/(DP*(1-(OR/2)))                               28.1, N
OF=OR/(DP*(1-(OR/2)))                                   28.2, N
DP=4                                                    28.3, C
OR=.2                                                   28.4, C
    YNC    - YOUTH ENROLLMENT CAPACITY (STUDENTS/YR)
    NC     - ENROLLMENT CAPACITY (PLACES)
    N      - ENROLLMENT (STUDENTS)
    GF     - GRADUATE FRACTION (PERCENT TOTAL
               ENROLLMENT/YR)
    OF     - DROPOUT FRACTION (PERCENT TOTAL ENROLLMENT/
               YR)
    XPAA   - PHYSICAL PLANT ADDITIONS ARRIVING (PLACES/
               YR)
    XP     - PHYSICAL PLANT (PLACES)
    XPDF   - PHYSICAL PLANT DISCARD FRACTION (1/YR)
    OR     - DROPOUT RATE (PERCENT OF ENTRANTS WHO FAIL
               TO GRADUATE)
    DP     - DURATION OF PROGRAM (YEARS)

G.K=N.K*GF                                              29, A
    G      - GRADUATES (STUDENTS/YR)
    N      - ENROLLMENT (STUDENTS)
    GF     - GRADUATE FRACTION (PERCENT TOTAL
               ENROLLMENT/YR)
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O.KL=N.K*OF                                                  30, R
    O        - DROPOUTS (STUDENTS/YR)
    N        - ENROLLMENT (STUDENTS)
    OF       - DROPOUT FRACTION (PERCENT TOTAL ENROLLMENT/
                 YR)

E.K=E.J+(DT)(HG.JK+HU.JK-F.JK-R.JK)                          31, L
E=EN                                                         31.1, N
EN=400                                                       31.2, C
    E        - EMPLOYMENT (WORKERS)
    HG       - HIRES FROM GRADUATES (WORKERS/YR)
    HU       - HIRES FROM UNEMPLOYED (WORKERS/YR)
    F        - FIRES (WORKERS/YR)
    R        - RETIRES (WORKERS/YR)
    EN       - INITIAL EMPLOYMENT (WORKERS)

HG.KL=AHG.K                                                  32, R
    HG       - HIRES FROM GRADUATES (WORKERS/YR)
    AHG      - HIRES FROM GRADUATES (SAME AS HG) (WORKERS/
                 YR)

AHG.K=MIN(HD.K,HGA.K)                                        33, A
    AHG      - HIRES FROM GRADUATES (SAME AS HG) (WORKERS/
                 YR)
    HD       - HIRES DESIRED (WORKERS/YR)
    HGA      - HIRES FROM GRADUATES AVAILABLE (WORKERS/YR)

HGA.K=G.K*HGAF                                               34, A
HGAF=1                                                       34.1, C
    HGA      - HIRES FROM GRADUATES AVAILABLE (WORKERS/YR)
    G        - GRADUATES (STUDENTS/YR)
    HGAF     - HIRES FROM GRADUATES AVAILABLE FRACTON
                 (PERCENT/YR)

HU.KL=MIN(HD.K-AHG.K,HUA.K)                                  35, R
    HU       - HIRES FROM UNEMPLOYED (WORKERS/YR)
    HD       - HIRES DESIRED (WORKERS/YR)
    AHG      - HIRES FROM GRADUATES (SAME AS HG) (WORKERS/
                 YR)
    HUA      - HIRES FROM UNEMPLOYED AVAILABLE (WORKERS/
                 YR)

HUA.K=U.K*HUAF                                               36, A
HUAF=1                                                       36.1, C
    HUA      - HIRES FROM UNEMPLOYED AVAILABLE (WORKERS/
                 YR)
    U        - UNEMPLOYMENT (PERSONS)
    HUAF     - HIRES FROM UNEMPLOYED AVAILABLE FRACTON
                 (PERCENT/YR)

F.KL=FD.K                                                    37, R
    F        - FIRES (WORKERS/YR)
    FD       - FIRES DESIRED (WORKERS/YR)
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R.KL=E.K*RF                                                38, R
RF=.1                                                      38.1, C
     R       - RETIRES (WORKERS/YR)
     E       - EMPLOYMENT (WORKERS)
     RF      - RETIREMENT FRACTION (PERCENT/YR)

HD.K=MAX(CED.K,0)                                          39, A
     HD      - HIRES DESIRED (WORKERS/YR)
     CED     - CHANGE IN EMPLOYMENT DESIRED (WORKERS/YR)

FD.K=MAX((-1)*CED.K,0)                                     40, A
     FD      - FIRES DESIRED (WORKERS/YR)
     CED     - CHANGE IN EMPLOYMENT DESIRED (WORKERS/YR)

EO.K=HD.K-FD.K                                             41, A
     EO      - EMPLOYMENT OPPORTUNITY (JOBS/YR)
     HD      - HIRES DESIRED (WORKERS/YR)
     FD      - FIRES DESIRED (WORKERS/YR)

CED.K=SWITCH(E.K*GT.K,ET.K-E.K,SSO)+HRR.K                  42, A
SSO=0                                                      42.1, C
     CED     - CHANGE IN EMPLOYMENT DESIRED (WORKERS/YR)
     E       - EMPLOYMENT (WORKERS)
     GT      - GROWTH TREND (PERCENT/YR)
     ET      - EMPLOYMENT TREND (JOBS)
     SSO     - SOCAL SERVICE OCCUPATON SWITCH (0=
                 PRODUCTON,1=SOCIAL SERVICE)
     HRR     - HIRES TO REPLACE RETIRES (WORKERS/YR)

HRR.K=E.K*RF                                               43, A
     HRR     - HIRES TO REPLACE RETIRES (WORKERS/YR)
     E       - EMPLOYMENT (WORKERS)
     RF      - RETIREMENT FRACTION (PERCENT/YR)

U.K=U.J+(DT)(UG.JK+F.JK-HU.JK-ULO.JK)                      44, L
U=UN                                                       44.1, N
UN=800                                                     44.2, C
     U       - UNEMPLOYMENT (PERSONS)
     UG      - UNEMPLOYED FROM GRADUATES (PERSONS/YR)
     F       - FIRES (WORKERS/YR)
     HU      - HIRES FROM UNEMPLOYED (WORKERS/YR)
     ULO     - UNEMPLOYED LEAVING OCCUPATION (PERSONS/YR)
     UN      - INITIAL UNEMPLOYMENT (PERSONS)

UG.KL=N.K*GF-AHG.K                                         45, R
     UG      - UNEMPLOYED FROM GRADUATES (PERSONS/YR)
     N       - ENROLLMENT (STUDENTS)
     GF      - GRADUATE FRACTION (PERCENT TOTAL
                 ENROLLMENT/YR)
     AHG     - HIRES FROM GRADUATES (SAME AS HG) (WORKERS/
                 YR)
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ULO.KL=U.K*ULOF                                              46, R
ULOF=0                                                       46.1, C
    ULO     - UNEMPLOYED LEAVING OCCUPATION (PERSONS/YR)
    U       - UNEMPLOYMENT (PERSONS)
    ULOF    - UNEMPLOYED LEAVING OCCUPATION FRACTION
                (PERCENT/YR)
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FGU.K=SWITCH(0,UG.JK/(UG.JK+HG.JK),([illegible]K+HG.JK))   47, A
     FGU      - FRACTION OF GRADUATES UNEMPLOYED (PERCENT)
     UG       - UNEMPLOYED FROM GRADUATES (PERSONS/YR)
     HG       - HIRES FROM GRADUATES (WORKERS/YR)

GT.K=(ET.K-PET.K)/PET.K                                    48, A
     GT       - GROWTH TREND (PERCENT/YR)
     ET       - EMPLOYMENT TREND (JOBS)
     PET      - PAST EMPLOYMENT TREND (JOBS).

ET.K=SMOOTH(QT.K,QD)                                       49, A
QD=5                                                       49.1, C
     ET       - EMPLOYMENT TREND (JOBS)
     QT       - EXOGENOUS EMPLOYMENT TREND DATA (JOBS)
     QD       - EXOGENOUS DATA SMOOTHING DELAY (YEARS)

QT.K=TABHL(QTT,TIME.K,0,25,5)                              50, A
QTT=400/400/800/1500/1200/1000                             50.1, T
     QT       - EXOGENOUS EMPLOYMENT TREND DATA (JOBS)
     QTT      - EXOGENOUS EMPLOYMENT TREND DATA TABLE

PET.K=PET.J+(DT)(CET.JK)                                   51, L
PET=ET                                                     51.1, N
     PET      - PAST EMPLOYMENT TREND (JOBS)
     CET      - CHANGE IN EMPLOYMENT (JOBS/YR)
     ET       - EMPLOYMENT TREND (JOBS)

CET.KL=ET.K-PET.K                                          52, R
     CET      - CHANGE IN EMPLOYMENT (JOBS/YR)
     ET       - EMPLOYMENT TREND (JOBS)
     PET      - PAST EMPLOYMENT TREND (JOBS)
```