PLANNING DAYCARE SERVICES IN ISRAEL USING SYSTEM DYNAMICS

by

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ABSTRACT

Utilization ofa computerized simulation technique such as system dynamics [1] for planning public programs, such as daycare, offers administrators a way to select policies to cope with rapid changes in the organizational environment. Due to uncertainty in both the data and the behavioral assumptions of the model, the precise numbers produced should be accepted with caution. The essential usefulness of a system dynamics planning study is to evaluate the relative effectiveness of different policies taken to counter a shock to a social system. The shock in this study was a sharp cutback in new construction starts for daycare buildings. The various policies tested (increasing the new start building rate and changing children per class standards) were judged on their ability to restore lost service to the public resulting from the building cut. It was found that a system dynamics model of a social service system can offer administrators a tool for selecting among policy alternatives and for refining those policies which are found to be acceptable.

Introduction

This paper describes the results of a simulated planning study of daycare in Israel from 1974 to 1980. The daycare system in Israel is meant to include all of the various public and private organizations which engage in the care of children ages 0-5, that receive budgeted public funds for this purpose, and that are expected to maintain prescribed, ideal standards of childcare service.

The daycare system modeled herein is composed of three groups, each of which receives children from a particular age population, these are: group one from ages 0 to 1.5 years; group two from ages 1.5 to 3 years; and group three from ages 3 to 5 years. Each of these populations comprises approximately one third of the total. However, their ideal coverage rates (fraction attending daycare) are much different (10 percent, 20 per cent and 95 per cent for groups 1, 2 and 3 respectively). This results in the bulk (approximately 80 per cent) of children in daycare being enrolled in group 3, ages 3-5 years.

To give some idea of the daycare system in 1974, there were: for group one, 8,000 children enrolled out of a population of 139,000; for group two, 17,000 children out of 131,000; and for group three, 105,000 out of 148,000.

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1 System dynamics is a computer simulation technique developed by Professor J. W. Forrester of Massachusetts Institute of Technology. It has been applied to various socio-economic systems. See the following by J. W. Forrester: Industrial Dynamics, MIT Press, Cambridge, Mass. (1961); Principles of Systems, Wright-Allen Press, Cambridge, Mass. (1968); Urban Dynamics, MIT Press, Cambridge, Mass. (1969); World Dynamics, Wright-AllenPress, Cambridge, Mass. (1971).

The ideal standards of performance used herein involved children per class and per teacher ratios. For groups one and two, 40 children per class were prescribed; for group three, 25 children per class. For all groups, two classes per building were assumed. For standards of children per teacher, the ratios were 5:1 in group one and 10:1 in groups two and three. For standards of children per trained teacher, the ratios were 10:1 in group one and 25:1 in groups two and three.

Background

This model was originally designed for the purpose of planning key daycare variables--children, staff, buildings and budgets--under assumptions of various coverage rates from 1974 to 1980. The model was nearly completed when the Rabin Government announced an immediate halt of new public building starts in Spring, 1974. This sudden decision provided an excuse to demonstrate the effect of an environmental shock on a planned social service system, i.e. daycare services to children ages 0-5.

The cutback in building also provided an opportunity to experiment with various countermeasures for the purpose of recovering projected losses in daycare resulting from the decrease in buildings. These countermeasures included both an increase in the new start rate in the years following the cutback and a lowering of certain standards of performance of the daycare system.

The sections which follow will discuss: the question for which answers were sought; a summary of findings; the assumptions of the model; a brief description of the model structure; a sample of results; and, finally a discussion of social system behavior under shock.

Questions

The following questions are those which were of paramount concern in the system dynamics simulation for a national daycare plan in the period 1974-1980.

*What are the losses in daycare service to the public (in units of childyears [2] as a result of a cut in public building in 1974-1976?

*To what extent does an increased building rate after 1976 influence the recovery of daycare service losses?

*By how much should the children per class standards be changed to recover daycare service losses?

*What are the values of children, staff, buildings and budgets projected for the years 1974 to 1980 under various alternative policies?

Summary of Results

A summary of the principal findings are listed below. Table 1 presents values of key system variables for the most important policy alternatives. The results are:

*Daycare service losses of 5.3 per cent (47.5 thousand childyears) result from a new building start cutback plus a feedback policy of restricting admissions to daycare if feedback was not in force before cutback and if standards are maintained.

*Daycare service losses of 2.1 per cent (18.1 thousand childyears) result from a new building start cutback if the feedback policy was already in force before cutback, if standards are maintained.

*Increasing the building rate after 1976 has no effect on recovering the losses in day care services.

2 One childyear of service is defined as the service given to one child attending daycare for one year.

* The 5.3 per cent loss in daycare service may be recovered by admitting three more (or 28) children per class in the group 3-5 years of age. Normal class size for this group is 25 children.

* The 2.1 per cent loss in daycare service may be more than recovered by admitting one more child per class (26 children) in the 3-5 age group.

These results reveal that placing a small number of additional children in each class of age 3-5 (holding other ideal standards constant) is sufficient to recover losses in daycare service.

The results also rule out the policy of increasing the building rate after 1976 to recover daycare service losses. The reason for this, which will become apparent from the model structure, is that a three year period is required for developing a new building. Increased building rates begin, therefore, to affect the system in 1979, too late to recover daycare losses by 1980.

The feedback of buildings on admissions of additional children to daycare will be discussed in the following section dealing with assumptions. It was found to play a crucial role in determining the losses of daycare services.

Values of key system variables--children, staff, buildings and budgets--were obtained each year of the program for each alternative shown in Table 1. A sample of these results is given in a later section.

Assumptions

Administrative foresight: The model is driven forward in time by a three year advanced projection of the daycare child population. Plans for the development of new buildings and the education of new trained staff are based on these daycare population projections. Underlying this projection is the assumption of a certain amount of foresight on the part of daycare administrators with respect to buildings and trained staff needed in the three year coming period.

The projection operates as follows. From a trend of past births, a linear extrapolation is made for the years 1974 to 1983. Knowing the age composition for the children age 0-5 in 1974, calculations are then made to determine for each year the new population of children age 0-5. This is done by adding the births for the year and subtracting the 5-year old children. The assumption of the future birth rate is recognized as a source of possible error in the model.[3] It is, however, rectifiable as new data or better estimates of future births arise.

Once the child population has been projected, a gradually growing fraction of the population is assumed to attend daycare based on coverage goals. The result is a projection of the future daycare population from which a growth rate multiplier for the next three years can be determined.

3 Another source of error was the neglect of net immigration to Israel of children, age 0-5, which in the recent past equaled one percent of the 0-5 age population.

TABLE 1

VALUES OF KEY SYSTEM VARIABLES IN 1980

Description of run			Variable			
Building policy	Feedback cutoff from buildings to admissions	Ideal standard children per building--group 3	Cumulative childyears service (thousands)	Buildings in system	Cumulative building and development budget (millions IL)	Building per child relative to 1974
Initial values in 1974	-	50	0	2413	0	1.00
(1) Prescribed reduction	No	50	901.4	3171	259.2	1.02
(2) No reduction	No	50	901.4	3395	312.2	1.10
(3) Prescribed reduction	Yes	50	853.9	3176	261.0	1.04
(4) No reduction	Yes	50	872.0	3401	313.6	1.10
(5) Prescribed reduction	Yes	56*	901.4	2993	194.2	.97
(6) Prescribed reduction	Yes	52**	875.7	3105	235.3	1.01
(7) Prescribed reduction followed by increased rate of building	Yes	50	853.9	3276	307.8	1.08

* Recommended policy if no feedback (1) is assumed as base.

** Recommended policy if feedback (4) is assumed as base.

TABLE 2

POLICY MULTIPLIERS ASSUMED FOR NEW START BUILDING RATE

AND RESULTING DAYCARE SERVICE OFFERED FROM 1974-1980*

	Year													
New start policy	74		75		76		77		78		79		80	Cumulative childyears of service (thousands)
No reduction	1	1	1	1	1	1	1	1	1	1	1	1	1	872.0
Prescribed reduction	1	0	0	0.5	0.5	1	1	1	1	1	1	1	1	853.9
Prescribed reduction followed by increased rate	1	0	0	0.5	0.5	1	1.2	1.4	1.4	1.4	1.2	1	1	853.9
Reduction to zero followed by slow recovery	1	0	0	0.2	0.4	0.6	0.8	1	1	1	1	1	1	849.5

* Feedback is assumed here with an ideal standard of 25 children per class in group age 3-5 years.

It is the three year growth rate multiplier of day-care children that is used by administrators to determine both new start building rate and admission rates to trained staff colleges. In both cases, the rates are determined by calculating the needed level (trained staff or buildings) in three years, subtracting from it the actual current level, and dividing the difference by the time required to reach the needed level, i.e. three years.

Cutoff from feedback loop: One negative feedback loop exists in the model, that of buildings needed restricting additional children to daycare above the replacement rate. It works as follows: If the number of buildings needed to meet children-per-class standards exceeds the existing number, then an automatic cutoff of additional admissions to daycare classes occurs. This feedback loop is activated only during those intervals in which buildings currently needed exceed the stock of buildings currently in the system.

Unlimited trained staff: The model assumes an unlimited supply of untrained staff available in the environment. During the early years of the period, when trained staff is being educated, untrained staff are hired in large numbers to meet teacher/child ratio standards. Later as trained staff begin to enter the system, the numbers of untrained staff decline. The assumption of unlimited availability of untrained staff corresponds to the current situation within the environment today.

Unlimited staff and operations budgets: The model assumes an unlimited supply of funds available for staff budgets and operations budgets of existing buildings. This assumption is partly based on a high priority for daycare. Israeli society encourages its women to enter the chronically labor-short economy.

There is a second argument for the provision of funds for daycare, the professed aim of closing the social gap by providing culturally enriching experiences for children of large, poor families.

Staff budgets are calculated from the number of trained and untrained staff multiplied by their respective yearly costs. Building operations costs are determined from the numbers of buildings being used times the average yearly cost per building.

New start building rate: For those runs in which a prescribed cut in new start building rate is assumed, the rate is set to zero in the six month period from July to December, 1974, then it is increased to one-half of the normal rate from July to December, 1975. Thereafter, the building rate is assumed normal. Table 2 presents four sets of building rate policy multipliers along with the cumulative daycare service offered for each set. The largest service is offered if the policy multiplier remains at 1.0 throughout the period. Increasing the policy multiplier after 1976 results in no gain whatsoever in childyears of service. Decreasing the rate of recovery of the policy multiplier results in only a slight decline in the service offered.

Model Structure

A schematic diagram of the principal model components and their causal interactions are shown in Fig. 1. The positive (negative) sign of the arrows means than an increase in the affecting component will result in an increase (decrease) in the affected component. For example, an increase in trained staff, with total staff held constant, results in a decrease in untrained staff.

As has been previously discussed, the model contains one negative feedback loop, between total buildings needed and admission of additional children to daycare. All of the other relationships in the model feed forward causally. For example, an increase in students in training causes an increase later in trained staff and results in increased budgets for students and staff. An increase in new building rates has a similar effect of increased buildings in development, buildings in use, and budgets for development and operations.

It is possible to insert additional feedback loops into the model to account for shortages of trained staff or of budgets if these situations should arise. Because of the relatively small size of the daycare program compared to its ideal coverage of the child population, these potential feedback loops were excluded for the 1974-1980 period. The overall tightening of the national budget in Summer, 1974 would seem to pose an indirect threat to daycare system growth. In any future modeling of daycare, staff and budget feedback loops may have to be added to the existing building feedback loop.

Detailed Structure

A more detailed structure of the principal flows, rates and levels in the subsystems of daycare is shown in Fig. 2. The four subsystems include: child population in the environment; children in daycare; trained and total staff; and buildings in development and in use. There are many auxiliary variables which link these subsystems and their components but which are not shown or discussed for sake of brevity.

The substance flowing within each subsystem (children, staff or buildings) originates in the environment, traverses the subsystem, and then exits to the environment. Rates of flow are controlled by valve symbols. Levels of components, denoted by rectangles, are determined from the level in the previous time interval, plus the inflow minus the outflow during the interval. For a complete explanation of system dynamics flow charts, see the work of Forrester (footnote 1).

Sample of Results

A typical graphical output from the daycare model is shown in Fig. 3. The run selected is that of Row 5 of Table 1: a prescribedcut in new building starts; feedback of buildings on admissions; and 56 children per building (28 per class) in Group 3. The variables plotted are: total children in daycare (C); yearly total (operations plus staff) budget (B); additional trained staff above the 1974 level (S); and yearly building development budget (D).

Each of the above variables is computer plotted as a function of time. The vertical axis indicates each variable's magnitude. Children in daycare are scaled in thousands (T); total budget and building development budget are scaled in millions of 1974 lirot (M).[4] Similar kinds of graphical outputs were obtained for every important rate, level or auxiliary variable of the system.

It is seen from Fig. 3 that three of the variables, children in daycare, total budget and additional staff initially increase over the period. The fourth, building development budget, does not. Because of the cutback in new start rate, the building development budget decreases slightly and then begins to climb after 1976. Thus, the cutback in new building starts has its strongest impact on preventing a rapid rise of the building budget early in the period. After the cutoff ends in 1976, the building development budget increases very rapidly in the remainder of the period in an attempt to "catch up" on the projected buildings needed in the system.

Remarks on the Behavior of Social Service Systems Experiencing Environmental Shock

A shock to a social service system, such as a cut in new building construction, causes key system variables to depart from their non-shock levels. The system then attempts to return to its original path after the shock passes. This occurs because rates of change of key system variables are based ultimately upon advanced projections and keyed to prescribed performance standards (e.g. children per building and children per teacher ratios).

A temporary cutback in a variable, such as buildings, at an earlier time results in a greater discrepancy between the actual and the ideal level for the variable, thereby increasing the "normal" rate once the cut is later rescinded. Consequently, many key system variables (e.g. buildings, trained staff, children in daycare) arrive at approximately the same levels by 1980 although they traversed different paths.

The most pronounced effects on system behavior result, however, from insertion of a structural change in the model, such as a feedback loop, and not because of a shock from the environment. If the social service system already contains a number of feedback loops sensitive to deviations from ideal system performance standards, then it will far better be able to cope with environmental shock by marginally reducing standards of service. The particular standards to be altered and the precise amount of change necessary may be determined by experimenting with a system dynamics model of the social service system. This was shown to be the case for the simulation of the Israel daycare system in the period 1974-1980.

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4 The exchange rate was 4.2 Israeli lirot per dollar in 1974.

Acknowledgements

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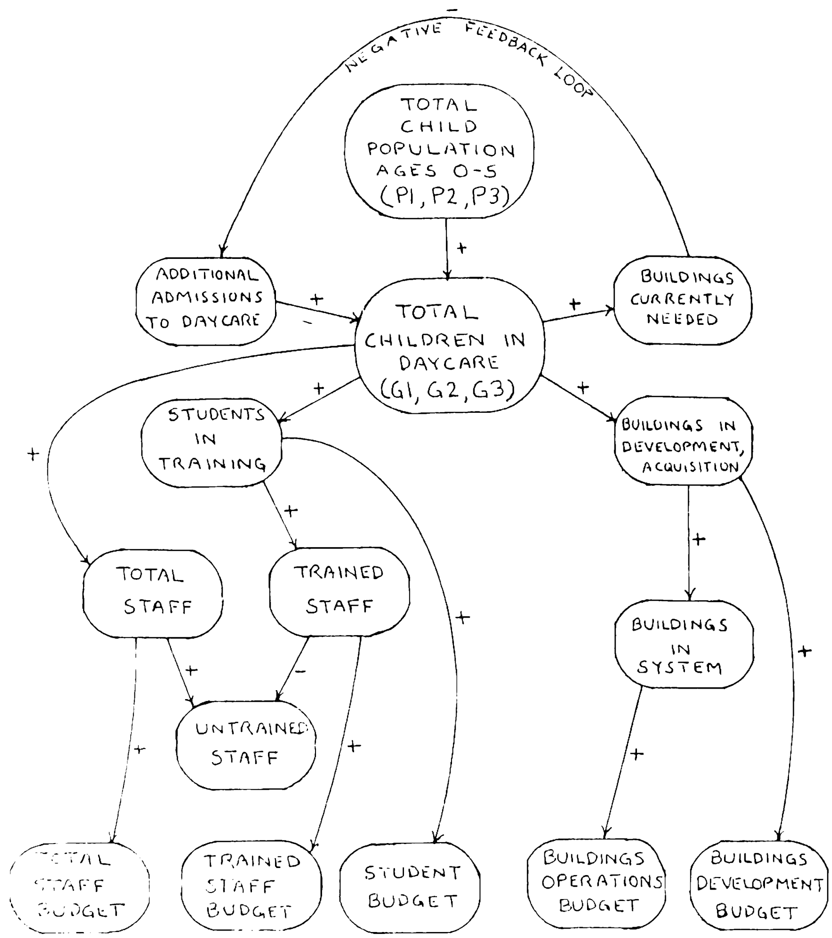

+ = POSITIVE INFLUENCE AND − = NEGATIVE INFLUENCE FOR CAUSAL AGENT INCREASE

FIG. 1: SCHEMATIC DIAGRAM OF PRINCIPAL COMPONENTS AND CAUSAL RELATIONSHIPS IN THE DAYCARE MODEL

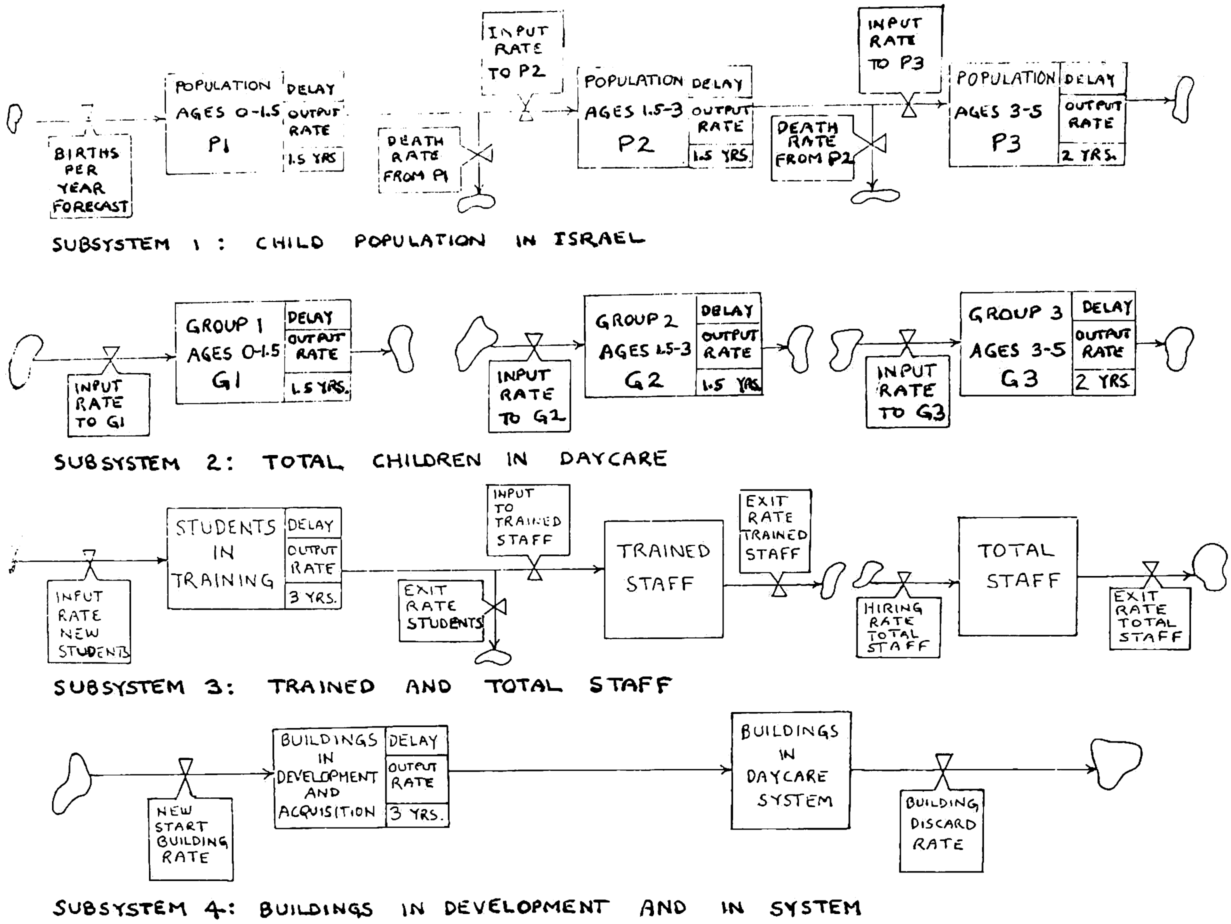

FIG. 2: FLOWS, RATES AND LEVELS IN SUBSYSTEMS OF DAYCARE MODEL

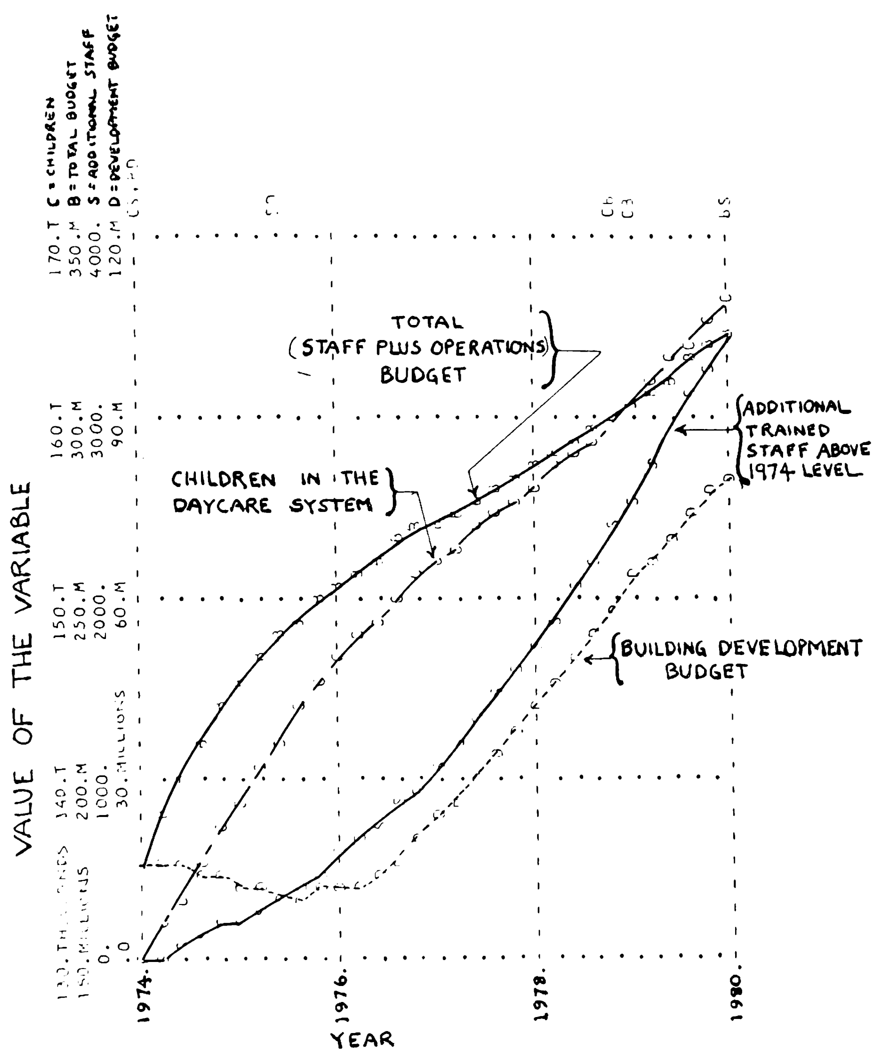

FIG. 3: SAMPLE OF GRAPHICAL OUTPUT FROM THE SYSTEM DYNAMICS MODEL ASSUMING: 28 CHILDREN PER CLASS IN GROUP 3; PRESCRIBED NEW START BUILDING CUT; FEEDBACK ON ADMISSIONS.