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CLIP   - A FUNCTION SWITCHED DURING THE RUN
TABHL  - A FUNCTION WITH VALUES SPECIFIED BY A TABLE
FCET   - FCE TABLE
FCFPC  - FERTILITY CONTROL FACILITIES PER CAPITA
            (DOLLARS/PERSON-YEAR)
TIME   - CURRENT TIME IN THE SIMULATION RUN
FCEST  - FERTILITY CONTROL EFFECTIVENESS SET TIME
            (YEAR)
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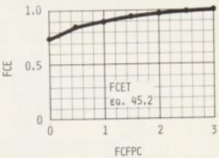

Table 2-77 Fertility control effectiveness table

The causal structure leading to fertility control effectiveness in World3 must be regarded as tentative, pending better information on the real costs and delays of implementing new fertility control methods. Our intent here was to emphasize that costs and delays do exist and that there must be a recognized need before society is willing to bear the costs of fertility control. A more detailed dynamic examination of this relationship might establish several causal chains incorporating different intrinsic delays. For example, a sudden decrease in desired total fertility DTF, which increases the need for fertility control NFC, may cause a small immediate increase in FCE as some people begin to utilize the high-cost methods already available, such as abortion and abstinence. This initial increase may then be followed by a larger increase, after a longer delay, as the new need stimulates the development of lower-cost methods, such as the IUD, which a larger fraction of the population may accept. The interesting behavior of Romanian fertility after abortions were made illegal in 1966 (David and Wright 1971) indicates that, at least in educated societies accustomed to effective fertility control, there may be a social response time of only a few years to adjust fertility control effectiveness to that needed by the population, even in the absence of modern fertility control technologies and government support.

Age-Structure Equations

We have already suggested that the determinants of population growth rates can be separated conceptually into two categories. The first consists of the many social and economic forces acting to increase or decrease mortality and fertility. This group of forces determines the aggregate probabilities of a person of a given sex and age dying or reproducing that characterize a population at any given time. The preceding description of the population sector equations has concentrated on our representation of this set of socioeconomic factors.

A second category of dynamic determinants of the behavior of the population system arises from the age structure of the population. These demographic determinants influence *how many* persons of each age and sex exist in the population at any time and are exposed to the mortality and fertility probabilities determined by the socioeconomic system.

Here we present three age-structure models at three different levels of complexity and accuracy that can be used interchangeably within the framework of the socioeconomic model to study the relative contribution of demographic factors to overall population behavior modes. The one-level population model, already described, essentially ignores the dynamics inherent in the population age structure. After reviewing that model, we discuss alternate age-structure models in order of increasing complexity, keeping in mind that for the purposes of this model we are searching for the minimum degree of complexity necessary to represent the demographic contribution to population dynamics.

One-Level Population Model The following equations summarize the simplified assumptions contained in the one-level population model:

```
L      POP.K=POP.J+(DT)(B.JK-D.JK)
N      POP=POPI
C      POPI=1.61E9

R      D.KL=POP.K/LE.K
S      CDR.K=1000*D.JK/POP.K

R      B.KL=CLIP(D.JK,(TF.K*POP.K*FFW/RLT),TIME.K,PET)
C      FFW=.21
C      RLT=30
C      PET=4000
S      CBR.K=1000*B.JK/POP.K
```

These equations imply that women of reproductive age constitute a constant fraction of the population, that death occurs with equal probability to persons of all ages, and that changes in fertility or mortality probabilities have a single, instant effect on the population growth rate. These simple approximations would obviously not be permissible if the goal of the modeling process were short-term, accurate population prediction. For a long-term model designed only to investigate behavior modes, such approximations may be acceptable for the sake of simplicity of the model as a whole. The most serious dynamic defect of the one-level model is its omission of the delays inherent in the population age structure. For example, it implies that a 1 year-old child can immediately be counted as part of the reproductive population; it also implies that a 10 percent change in the mortality risk of 60-year-olds has the same effect on the population growth rate as a 10 percent change in the mortality risk of 1-year-olds. This failure to represent aging delays will certainly introduce error into the calculation of exact population growth rates. More important, it may alter the resultant behavior mode by which the population approaches an environmental limit or terminates a growth phase by ignoring a destabilizing delay between an environmental stimulus and a demographic response. Therefore, we must investigate more accurate ways of representing the delays in the age structure of the population, by disaggregating the single population level.

Four-Level Model Two population age groups are of particular interest for relationships elsewhere in World3: the reproductive population (as an input to the birth