BERKELEY-STANFORD

ECONOMIC HISTORY SEMINAR

Evolution and Economic History

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and
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Thursday, May 25, 1989

Faculty Club
University of California, Berkeley

We shall gather in the bar at 6:30 or so and adjourn for dinner in the Latimer Room at 7:00. Our guest will speak after dinner. Participants will be assessed for their meal and drinks at a probable cost of $22 to $24.

If you wish to attend, please contact Dorothy Kelly at Berkeley (415) 642-1922 or Kimberly Ling at Stanford (415) 723-9767 by Thursday, May 18.

SELECTIVE PRESSURE AND ECONOMIC HISTORY: ECONOMICS IN THE VERY LONG RUN

Gregory Clark and Alan P. McGinley

May 25, 1989

Economists and economic historians often take as a basic premise of their discipline certain attributes of people and certain social rules. Thus we regard it as unexceptional to view people as having positive rates of time preference, as being risk averse, as having a certain number of children, as sharing family resources in certain ways between spouses and children, as leaving bequests to their children, and as following certain inheritance rules. Can we really take such attributes as parameters of the social world determined by accident in the same way as the gravitational constant is taken as a given parameter in physics? Or are there larger constraints on the type of behaviors that individuals are likely to display?

Two strategies can be conceived of to reduce these aspects of behavior to more basic elements. The first is to ground social rules and personal choices in more basic concerns of income maximization by individuals.[1] The problem with this approach is the informational and calculating abilities it seems to presume, and the positing of pure self interest as the motivation of individuals. When economists consider firms and the strategies they will adopt, however, they often resort to a different type of reasoning arguing that enterprises act **as if** they maximize profits and are risk neutral because only those firms with these characteristics will survive in the long run

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[1]This strategy is followed, for example, by Sundstrom and David (1988) who seek to explain the number of children farm couples in the U.S.A. had in the nineteenth century through concerns on the part of parents about maximizing their lifetime consumption. Thus, "under identifiable conditions, rational parents would respond by reducing fertility" (Sundstrom and David (1988), p. 164).

(Alchain (1951), Nelson and Winter (1982)).

This second argument, the selection argument, is precisely the reasoning which has been used so powerfully in biology and sociobiology to explain the dominance of various behavior traits. We examine here what this second premise delivers in the way of constraining the types of behaviors exhibited by individuals.

The kind of society I want to consider is one where peasant agriculture dominates over a long period of time with little population growth because of a static agricultural technology. One example is Egypt up till the mid nineteenth century. Between 2500 BC and 1850 AD, a period of 4350 years, the population of Egypt is estimated to have varied between 1.6 million and 5.4 million (Butzer (1976), p. 82-5, Russell (1966), Panzac (1977), p. 158). Already by 150 BC the population had reached about 5 m, close to the level of the mid-nineteenth century. Figure 1 gives some rough population estimates by the date. Throughout this period most of the inhabitants of the country were peasant cultivators of an area of cultivable land lying along the Nile valley and in the Nile Delta. The extent of this area with the technology of 2500 BC was about 4 m acres, and this had grown to 6.8 m acres by 150 BC, compared to 6.7 m acres in 1881 (Butzer (1976), p. 82, Schanz (1913), p. 193). Thus population per acre of cultivable land in 2500 was 0.4 people, compared to about 0.8 people per acre by 150 BC, and in 1850.

In Egypt in 1909-13 the birth rate was about 58 per thousand (Panzac (1977), p. 166). Suppose that this was the birth rate over the preceding 4350 years from 2500 BC to 1850 AD, and the death rate had been on average 57 per thousand. Then the population by 1850 would have grown from 1.6 m to 124 m rather than to 5.4 m. The growth of population per cultivable acre was .0049% per year from 150 BC to 1850 AD. Thus there have been very tight constraints keeping the population of Egypt in line with the cultivable area until well into the nineteenth century.

Similarly the population of India in 300 BC has been estimated at circa 115 million, compared with a population from various estimates of about circa 180 million in 1850 (Chandrasekhar (1972), p. 247-8, Kumar (1983), p. 466) This implies a growth rate over 2150 years of .02% per year, or a average gap of .2 between birth and death rates per thousand. In the period 1871-1881 the birth rate is estimated at 45 per thousand (Kumar (1983), p. 508).

We have thus in Egypt a period of 2,000 years with no population growth in aggregate, or about 80 generations of 25 years. Over a longer period of 4,500 years, or 170 generations population growth is in aggregate extremely slow. In India we have about 90 generations where growth is very slow.

These seemingly static peasant societies have a number of interesting characteristics, though most of the information about them comes from the late nineteenth century onwards when population growth had become significant, presumably because some element of the stable configuration had been altered. These characteristics are:

1. Low investment rates, and a somewhat higher rate of return on capital compared to more advanced economies. Thus the return on land holding was estimated at 4-6% in India prior to 1913, and at 6-8% in Egypt, compared to 4-5% in Britain (Schanz (1913), pp. 224-5). Other types of lending are associated with much higher rates of return, but it is not known what the repayment prospects for such loans were. This even though in both India and Egypt there were ample opportunities for investment in land improvement and housing which required mainly labor inputs (irregation in the dry Deccan in India required for example the levelling of fields and the building of embankments) (Keatinge (1912), p. 103-114).

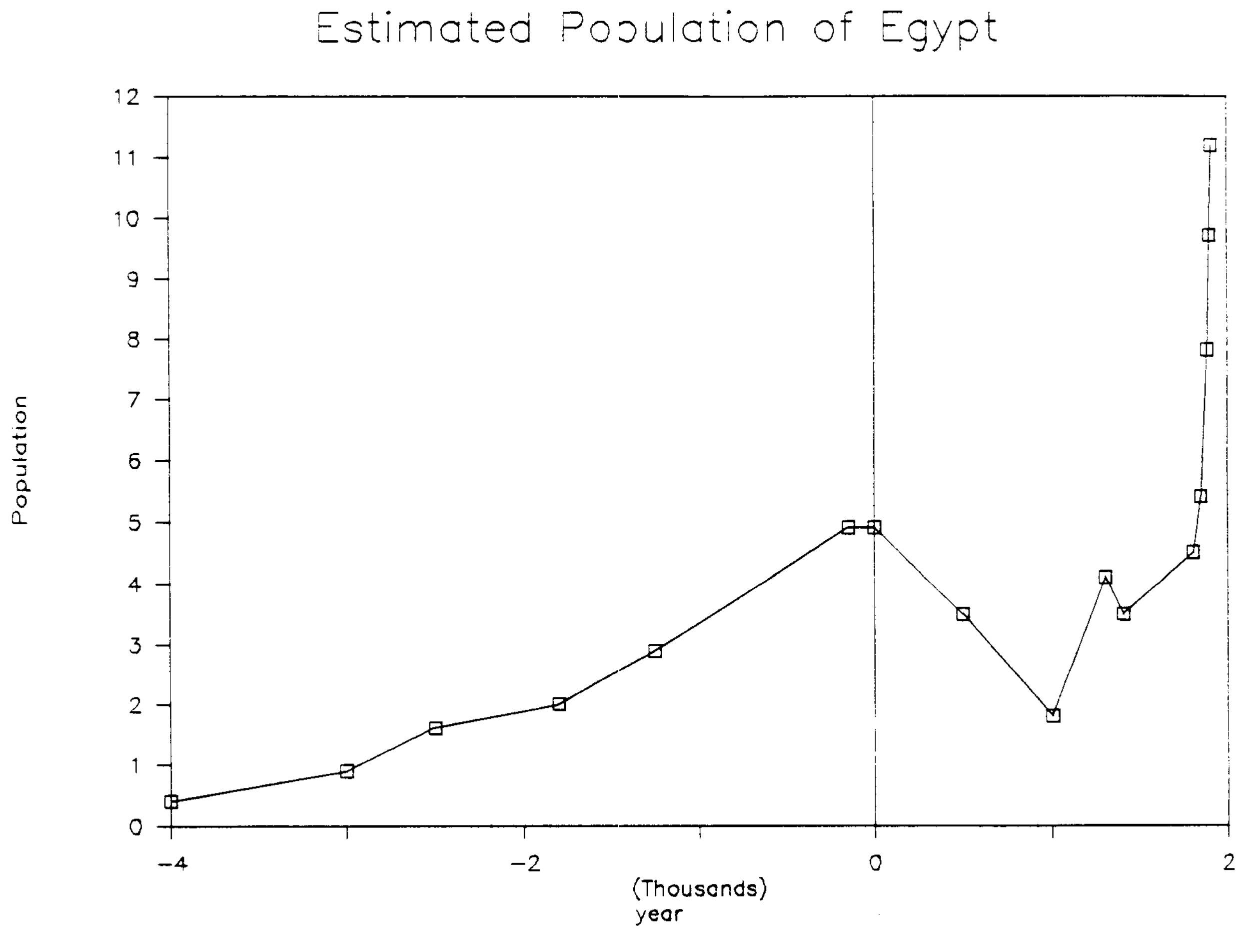


TABLE 1: DISTRIBUTION OF LAND OWNERSHIP, EGYPT 1910

area in feddan (=1.04 acre)	number of owners (000)	percentage of area
0	1050	0.0
0- 1	783	5.9
1- 5	464	16.3
5-10	76	8.6
10-20	37	8.2
20-30	11	4.0
30-50	8	5.3
50+	12	39.9
foreigners	8	11.7

Source: Schanz (1913), pp. 218-9.

2. Great inequality in land and capital holdings, and a class of workers in agriculture who subsist entirely on wage income. In 1907 in Egypt, for example, a period of rapid population growth and hence presumably of good economic times there were 2.44 m male workers in agriculture, whose land ownership was distributed as shown in Table 1. Thus large numbers of workers must have relied on their wage income alone.

3. A very low rural wage. The daily wage of agricultural workers in 1913 in Egypt was 2 - 4.5 Piastre Tarif, or $0.10 - $22.4, per day. In India in Ahmadnagar in the Deccan it was $0.04 - $0.10 per day from 1896-1910, corresponding to an average of 5.4 lbs of wheat grain (Keatinge (1912), p. 69, Statistical Abstract of British India (1917), p. 232). But since a lb. of wheat grain contains at least 1400 calories, the day wage would provide at least subsistence food for the wage laborer and some dependents. The agricultural wage in Egypt in Roman times seems to have been about the equivalent of 5 lbs. per day (Johnson (19__), p. 303).

4. Both fertility and mortality rates were high. In Egypt the birth rate circa 1913 was about 59 per thousand. In 1960 when the birth rate was 50 per 1000 the number of live births per married woman of age 45 years or more was 6 (Panzac (1977), p. 169). At a birth rate of 59 per thousand circa 1913 this would correspond, if there was the same rate of marriage formation, to 7.1 live births per married woman at age 45. Assuming almost universal marriage this implies a gross reproduction rate of 3.5. In India in 1891-1901 the crude birth rate was 51 per thousand, and the Gross Reproduction Rate 3.2.

5. Mortality was related to economic status. In India famines struck periodically from 1765 to 1913 (there were 31 recorded episodes of at least severe food shortage). The direct cause of most deaths was disease, but susceptibility to disease seems to have been related to economic status

through nutrition and living arrangements. In Mysore in 1952 agricultural laborers' families had an infant mortality rate of 159 per thousand live births, while the owner cultivator families had a rate of only 95 per thousand (Chandrasekhar (1972), p. 143). In Bombay from 1938-1947 the infant mortality rates of lower caste Hindus was 272 per thousand, for other Hindus it was 208, for Muslims 191, for Indian Christians 190, for Parsees 88, and for Europeans 62 (Chandrasekhar (1972), p. 147).

6. In both India and Egypt the rural population is both short and light compared to the population of economically developed countries.

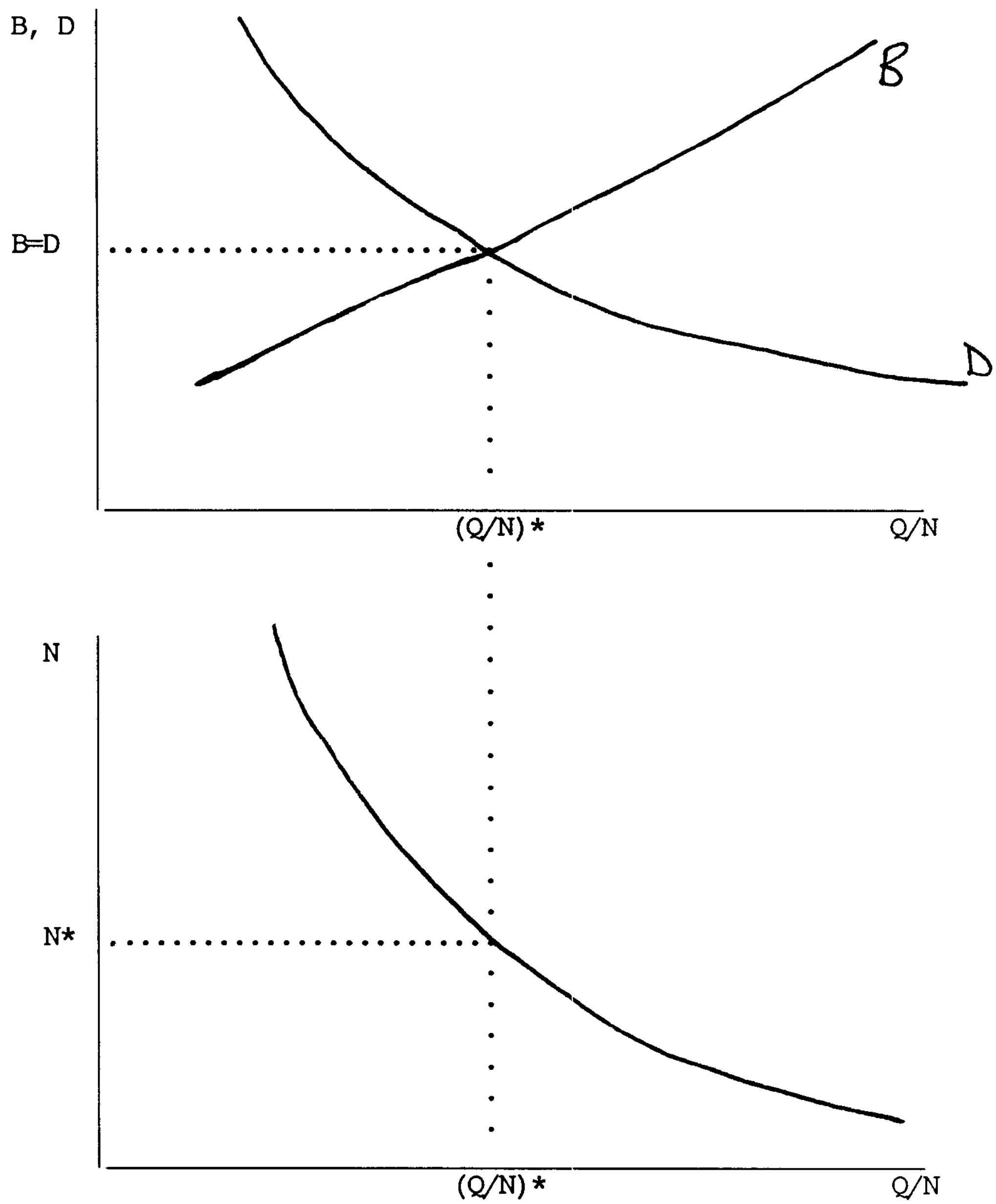
7. Cultivators are alleged to be very risk averse in their choice of techniques.

8. Peasants are alleged to be tightly bound by social custom and community pressures.

In a society whose population has changed little over periods of 1000 or more years there has to be a very powerful mechanism keeping population within bounds. The picture in Figure 2 portrays how we normally think population is kept in line with resources. In the first panel is shown both the birth rate, B, and death rate, D, as a function of income per capita, Q/N. In the second panel income per capita as a function of population, N. In the long run B = D, so that the population is kept in line with resources at the level N*. The regulatory force here is that death and birth rates are a function of income per capita.

With a population which is heterogenous in its income per capita and in its use of economic resources the population will be distributed along these B and D schedules, or will have B and D schedules relating their income to birth and death rates. Also the curve relating population N to output per worker

FIGURE 2: THE REGULATION OF POPULATION IN THE LONG RUN

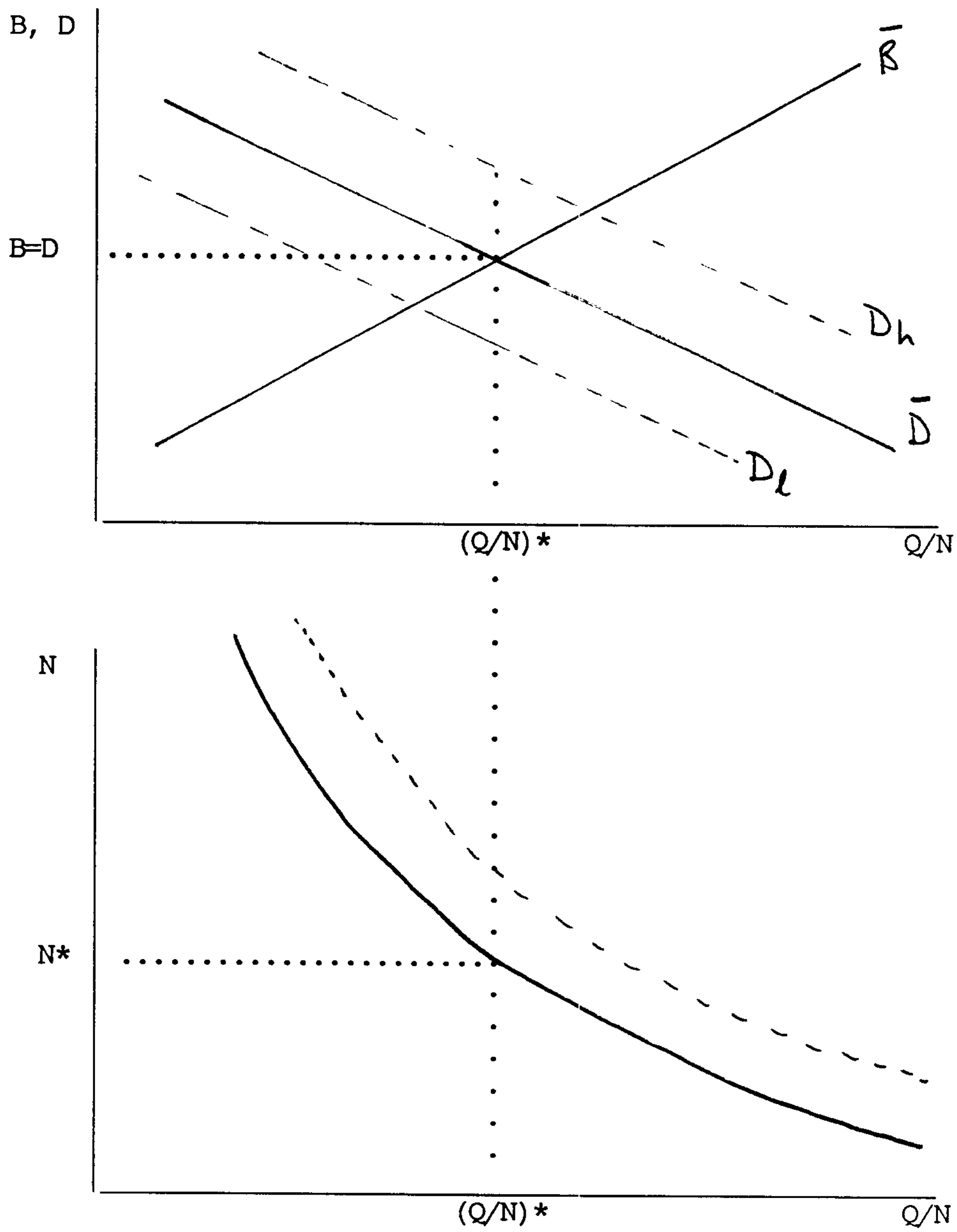


Q/N will depend on the amount of capital in the society which will in turn depend on the characteristics of the population. At $(Q/N) = (Q/N)^*$, B=D, but for many types of individuals in the population B > D, or B < D. If the offspring of individuals in the population inherit those characteristics in some way (there can be a large random component in this inheritance) then the proportion of different types in the population will change over time, as will the Q/N (N) schedule. In the sort of timespans we will consider below we are concerned with cultural inheritance more than with genetic inheritance.

Below we consider simple models in which individuals and their offspring compete for survival in a society with limited resources. The first dimension upon which people can vary is in their accumulation behavior. Over their productive years, which we assume to be 25 years, some persons spend all their income whilst others save varying proportions of income beyond wages or subsistence requirements which gets passed on to their children. Children inherit imperfectly the accumulation characteristics of their parent. The second dimension of behavior alone which people vary is the number of children they have. This characteristic is again passed on, but imperfectly, to their offspring.

If the survival chances of the individual and their offspring is dependent on the level of consumption then both these dimensions on which behavior can vary will produce differential survival chances. Consider the savings propensity. Individuals who over their livetime accumulate no net savings will be more likely to succomb in famine years, and will leave children who have fewer assets and thus lower incomes themselves. Consider the fecundity propensity. Individuals who have very few children will leave rich children, but there is also a chance if their is some background level of mortality that they will leave no surviving children. Individuals who have

FIGURE 3: POPULATION IN THE LONG RUN



many children will ensure many survivors, but they will be poor survivors affecting their chances of later breeding successfully.

The basic production technology we assume for the economy for all the models is,

$$Q_t = A_t . K_t^{\alpha} N^t{}_{\beta} T_t^{\tau}, \qquad A_t = \text{random}(0.8 - 1.2)$$

where Q is output (grain say), K is capital (seed say), N is labor, T is land (fixed), A is the state of the weather. With this specification,

$$w_t = \beta Q_t / N_t, \quad r_t = \alpha Q_t / K_t, \quad v_t = \tau Q_t / T_t,$$

where w, r, v are respectively the wage, rate of return on capital and rent of land. The price of land is $p_t = v_t/r_t$. Since T is fixed there are decreasing returns to the addition of capital and labor to the economy. Income is consumed or invested in capital. It is assumed in all the models that the consumption behavior of individuals is descibed by,

$$C_{it} = w_t + \Theta_i . (r_t K_{it} + v_t T_{it}), \qquad 0 \leq \Theta_i \leq 1$$
$$\text{if } C_{it} \geq \hat{c}$$

$$C_{it} = \hat{c}\ , \text{ if } w_t + K_{it} + p_t T_{it} \geq \hat{c}$$

$$C_{it} = w_t + K_{it} + p_t T_{it} \text{ if } (w_t + K_{it} + p_t T_{it}) \leq \hat{c}$$

$(1-\Theta_i)$ is the saving propensity out of property income. All wage income is consumed. The parent effectively has some given propensity to leave a bequest for their offspring. But if the economy hits a string of bad years this bequest can be consumed to sustain the individual. The investment of each individual is then described by,

$$(K_{it+1} + p_t T_{it+1}) = (K_{it} + p_t T_{it}) + (Y_{it} - C_{it})$$

What varies across the models is the processes by which individuals are born and die. In **Model 1**, the simplest accumulation model, the rules are,

> If $C_{it} \le \hat{c}$ then person dies. Every 25 years person gives birth to 2 offspring who each gets half their assets. The Θ_i of the offspring is the Θ_i of the parent plus random (-0.1, 0.0, 0.1).

There is thus a given subsistence minimum. People die either from old age or from falling below this minimum. The offspring inherit imperfectly the saving behavior of the parent.

In **Model 2**, a slightly more complicated accumulation model the birth and death rules are,

> If $C_{it} \le \hat{c}$ then person dies. Every 25 years person gives birth to 2 offspring. The chances of the second child surviving to maturity are given by,
>
> $$z = 1 - h(\mu_0 + \mu_1/(C_{it} - \hat{c})).$$
>
> If $z < 0.5$ then only one child survives. Assets equally distributed between surviving offspring. The Θ_i of the offspring is the Θ_i of the parent plus random (-0.1, 0.0, 0.1).

With these rules there is a more sloped death rate as a function of consumption, as is shown in Figure 4.

The other two models take Θ_i as fixed for all individuals at $\Theta_i = 0.47$ and instead allows the number of children born per person to vary. In **Model** 3 the birth and death rules are,

> If $C_{it} \le \hat{c}$ then person dies.
>
> Every 25 years person gives birth to 1 or 2 children, with the

probability of two children being ϵ_i. Assets are equally distributed between offspring. The ϵ_i of the offspring is the ϵ_i of the parent plus random (-1/15, 0.0, 1/15).

With this specification people always leave at least one surviving offspring. **Model 4** gives perhaps a more realistic determination of the number of surviving offspring.

If $C_{it} \leq \hat{c}$ then person dies.

Every 25 years person gives birth to Γ_i children, $0 \leq \Gamma_i \leq 6$. The Γ_i of the offspring is the Γ_i of the parent plus random (-0.5, 0.0, 0.5). The chance of each child surviving is indexed by

$$z = 1 - h(\mu_0 + \mu_1/(C_{it} - \hat{c}))$$

If $z < 0.5$ then the offspring dies before reaching maturity. Assets are equally distributed between surviving offspring. If no offspring survive the parent consumes all their assets in a final splurge.

The number of surviving children someone leaves thus depends on their fecundity Γ_i and their consumption C_{it}. The larger is μ_0 the greater is the background level of mortality of children which is independent of consumption levels.

PRODUCTION, CONSUMPTION, INVESTMENT MODELS 1-4

Production:

$$Q_t = A_t . K_t^{\alpha} N^{t}{}_{\beta} T_t^{\tau}, \qquad A_t = \text{random}(0.8,\ 1.2)$$

$$w_t = \beta Q_t / N_t$$

$$r_t = \alpha Q_t / K_t$$

$$v_t = \tau Q_t / T_t$$

There is only one good produced which is also the capital good.

Consumption:

1. $$C_{it} = w_t + \Theta_i . (r_t K_{it} + v_t T_{it}), \qquad 0 \leq \Theta_i \leq 1$$
   if $C_{it} \geq \hat{c}$

2. $$C_{it} = \hat{c}\ , \quad \text{if } w_t + K_{it} + p_t T_{it} \geq \hat{c}$$

3. $$C_{it} = w_t + K_{it} + p_t T_{it} \quad \text{if } (w_t + K_{it} + p_t T_{it}) \leq \hat{c}$$

$(1-\Theta_i)$ is the saving propensity out of property income. All wage income is consumed. The parent effectively has some given propensity to leave a bequest for his offspring.

Investment:

$$(K_{it+1} + p_t T_{it+1}) = (K_{it} + p_t T_{it}) + (Y_{it} - C_{it})$$

BIRTH, DEATH, INHERITANCE

MODEL 1: VARYING SAVING PROPENSITIES

If $C_{it} \leq \hat{c}$ then person dies.

Every 25 years person gives birth to 2 offspring who each gets half their assets. The θ_i of the offspring is the θ_i of the parent plus random (-0.1, 0.0, 0.1).

MODEL 2: SIMPLE ACCUMULATION MODEL

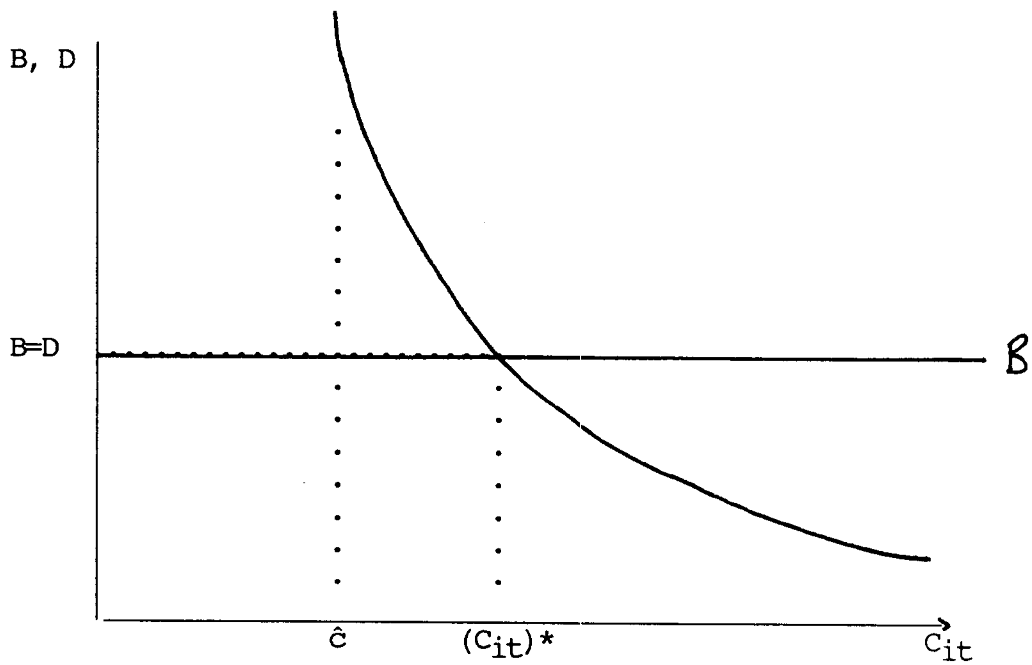
If $C_{it} \leq \hat{c}$ then person dies.

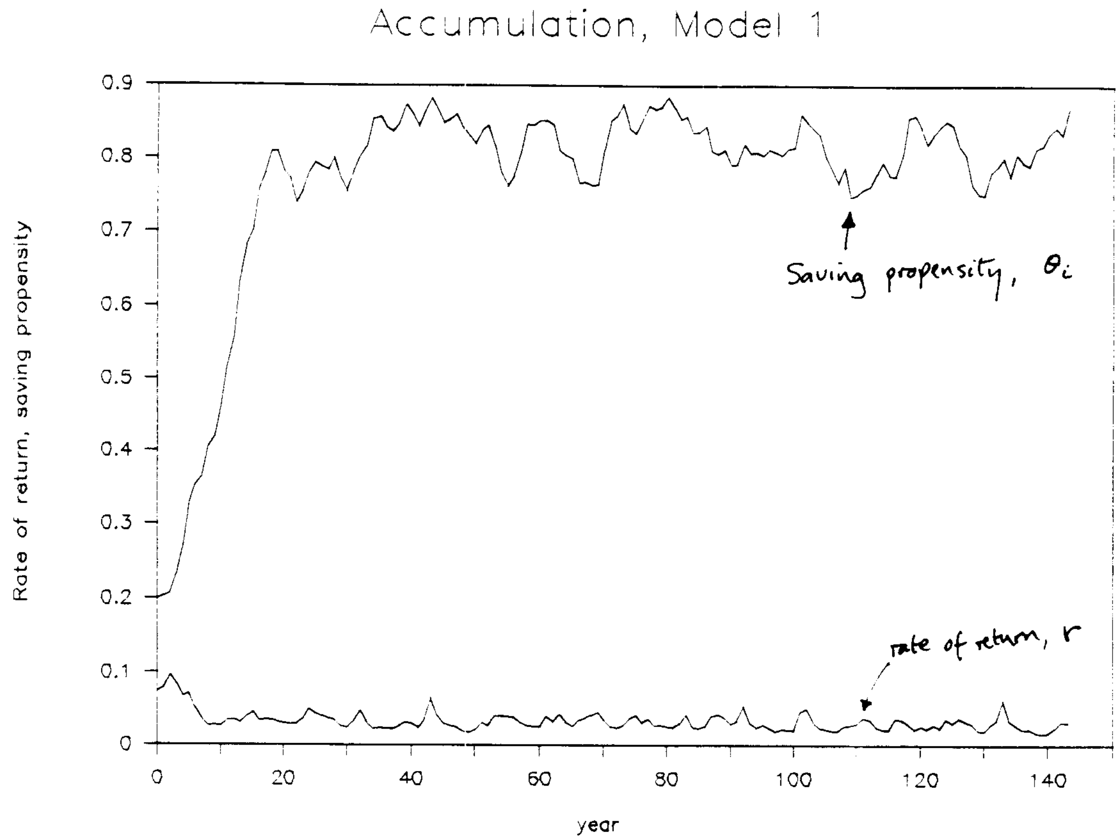
Every 25 years person gives birth to 2 offspring. The chances of the second offspring surviving to maturity are given by,

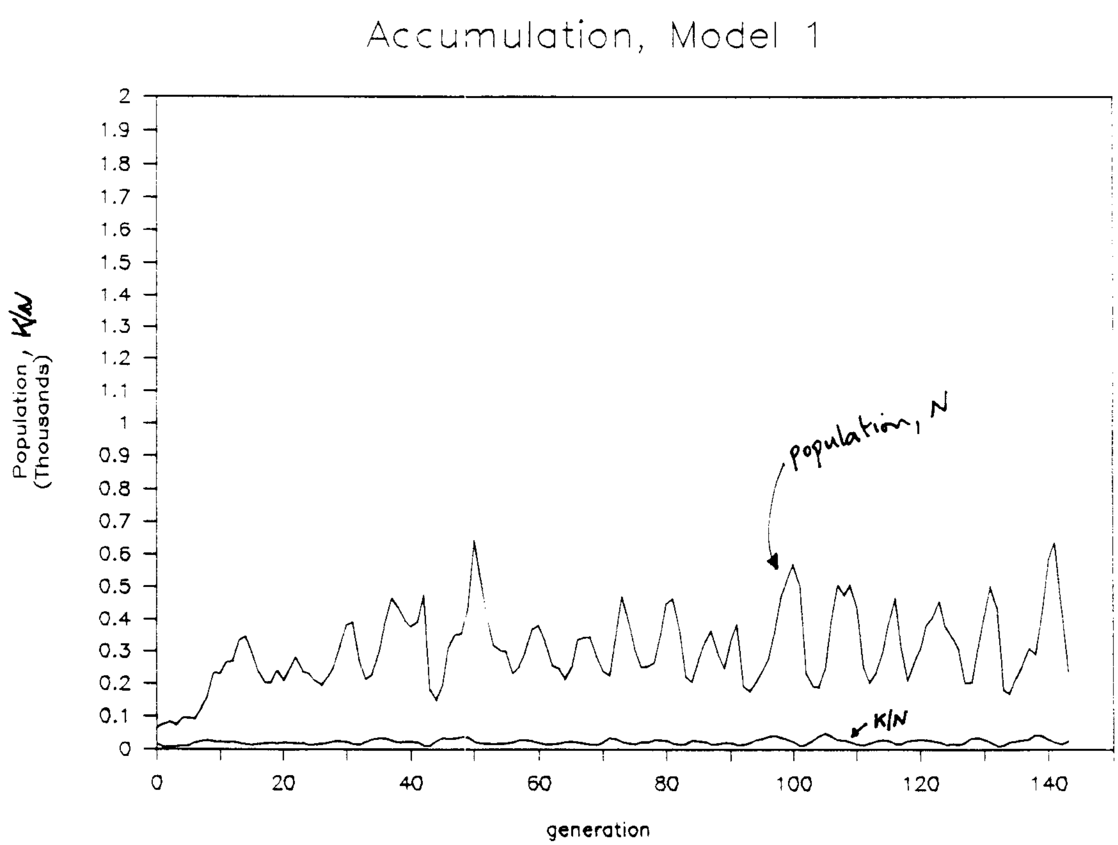
$$z = 1 - h(\mu_0 + \mu_1/(C_{it} - \hat{c}))$$

If $z < 0.5$ then only one offspring survives. Assets are equally distributed between surviving offspring. The Θ_i of the offspring is the Θ_i of the parent plus random (-0.1, 0.0, 0.1).

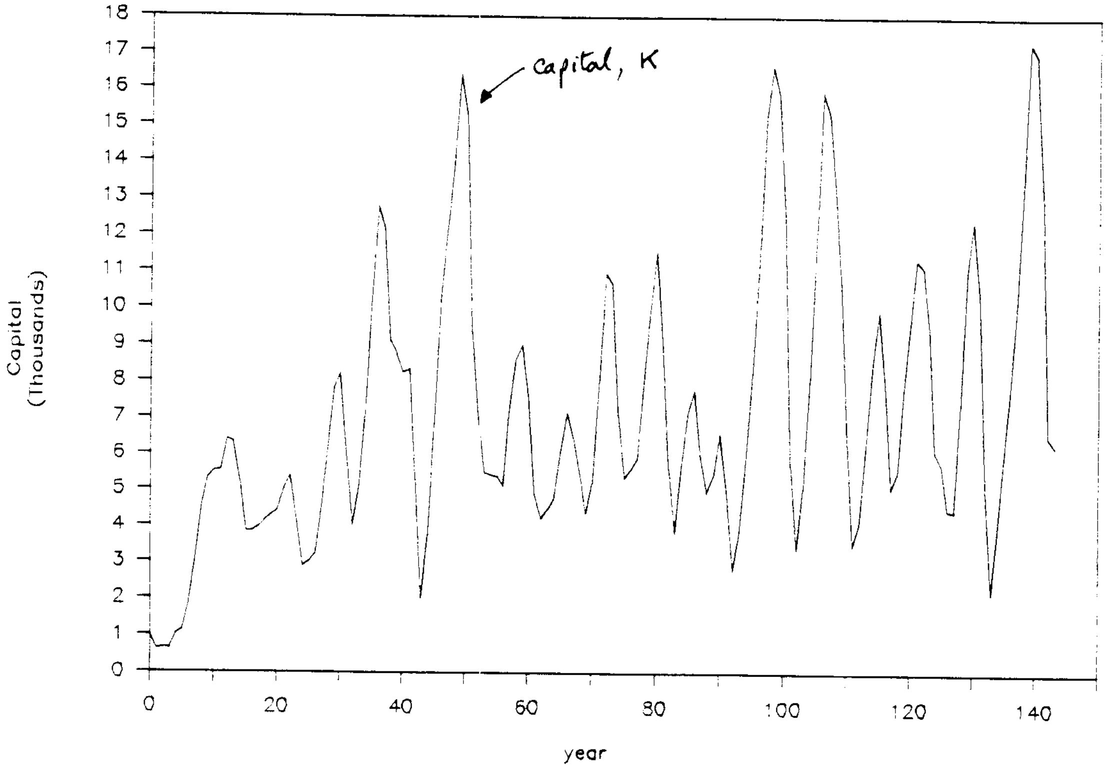
FIGURE 4: MODEL 2 ILLUSTRATED



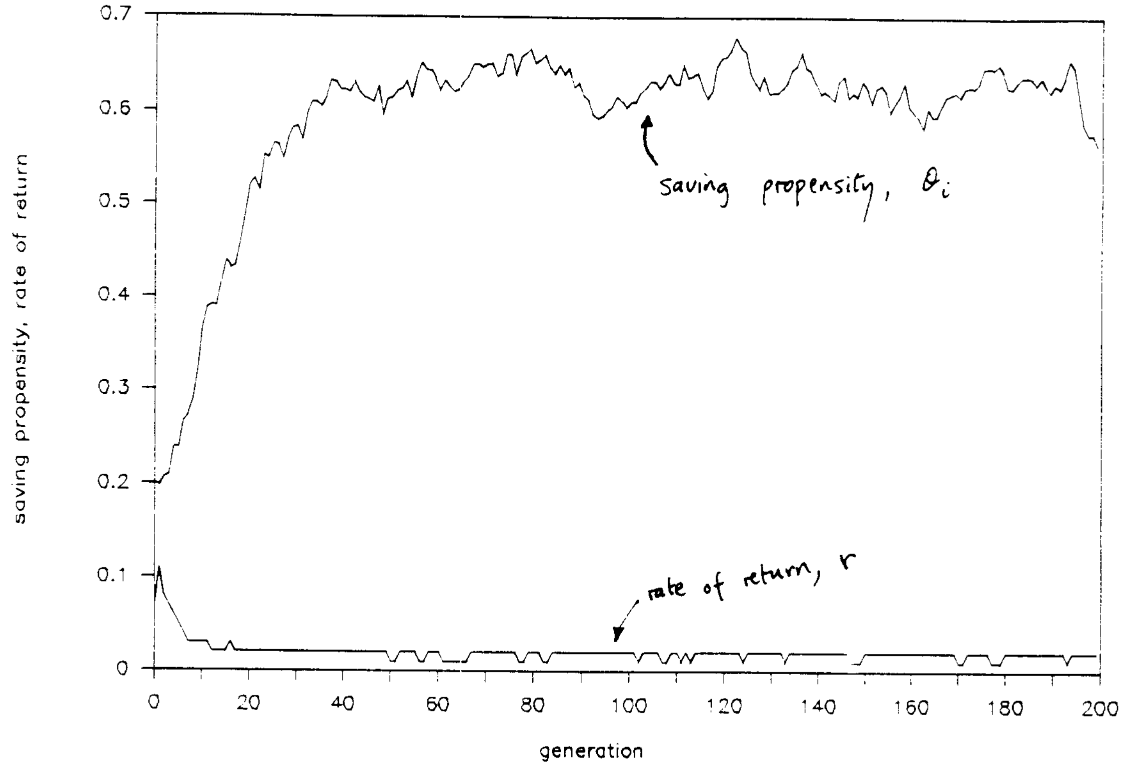

Accumulation, Model 1
Rate of return, saving propensity
Saving propensity, θ_i
rate of return, r
year
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9


Accumulation, Model 1
Population, K/N
(Thousands)
population, N
K/N
generation
0
20
40
60
80
100
120
140
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2

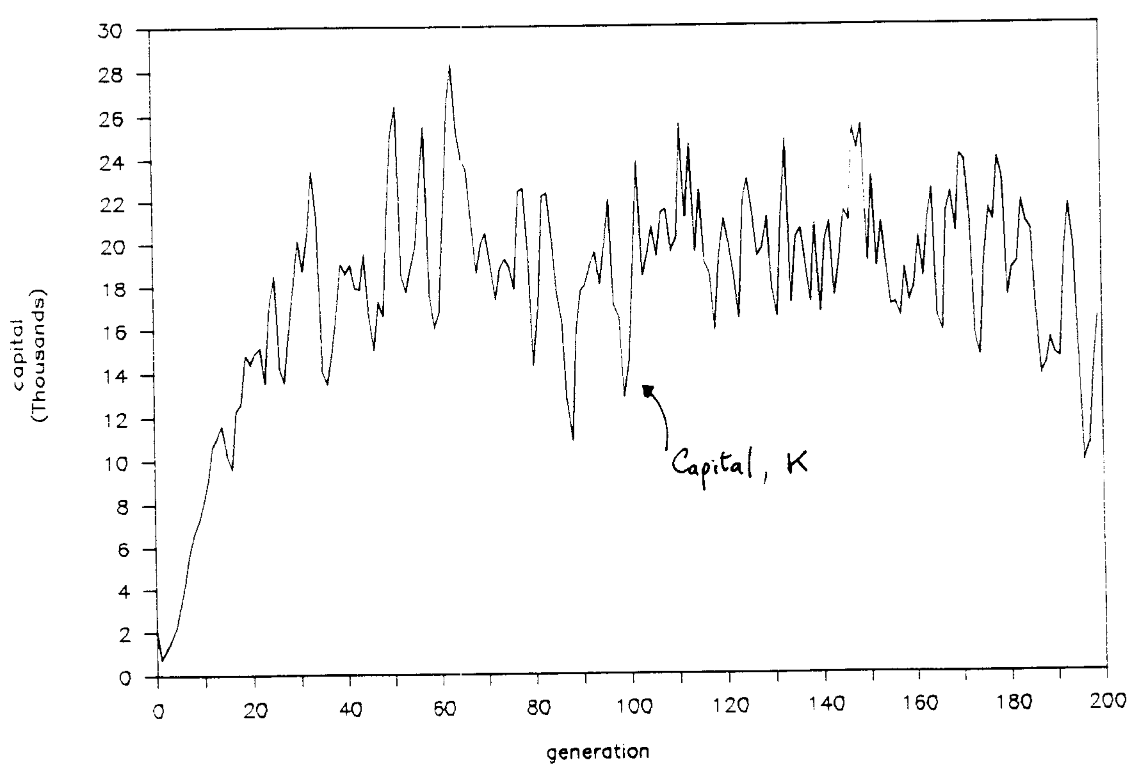
Accumulation, Model 1



Accumulation, model 2



Accumulation, model 2



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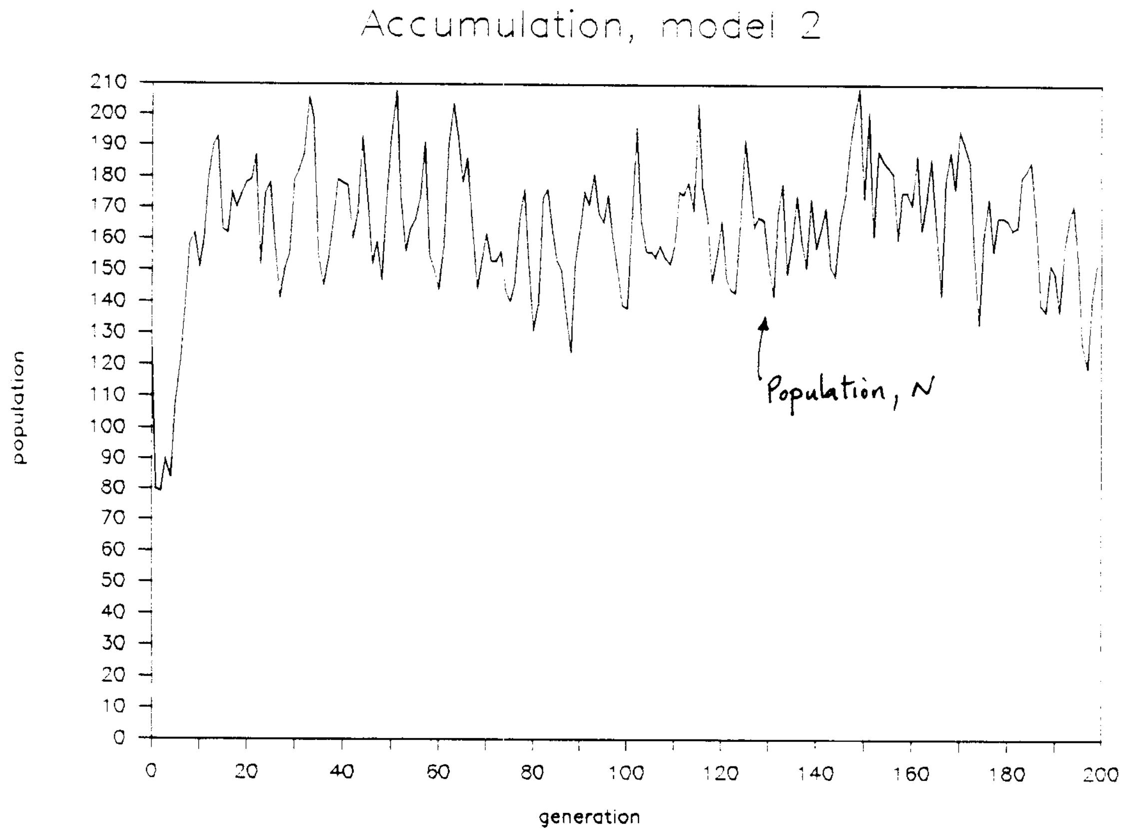


Accumulation, model 2
population
generation
Population, N
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200

MODEL 3: SIMPLE FECUNDITY MODEL

If $C_{it} \leq \hat{c}$ then person dies.

Every 25 years person gives birth to 1 or 2 children, with the probability of two children being ϵ_i. Assets are equally distributed between offspring. The ϵ_i of the offspring is the ϵ_i of the parent plus random (-1/15, 0.0, 1/15).

MODEL 3: MORE REALISTIC FECUNDITY MODEL

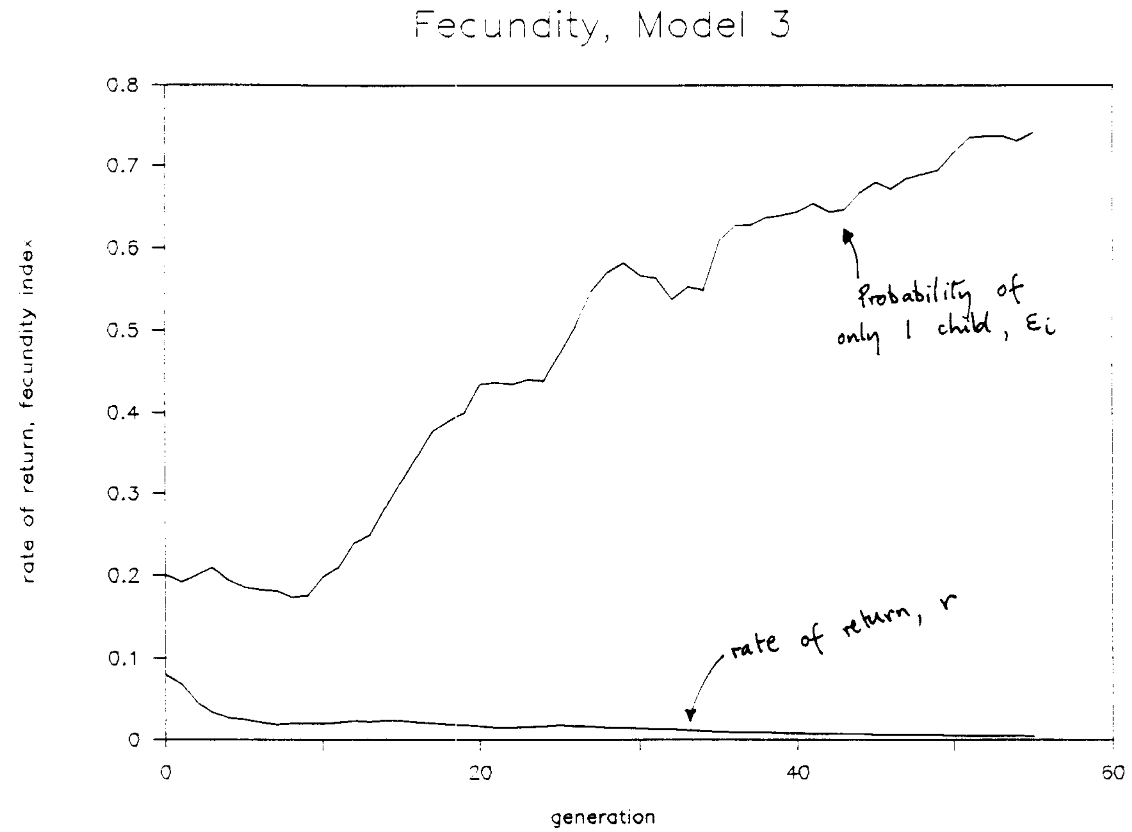
If $C_{it} \leq \hat{c}$ then person dies.

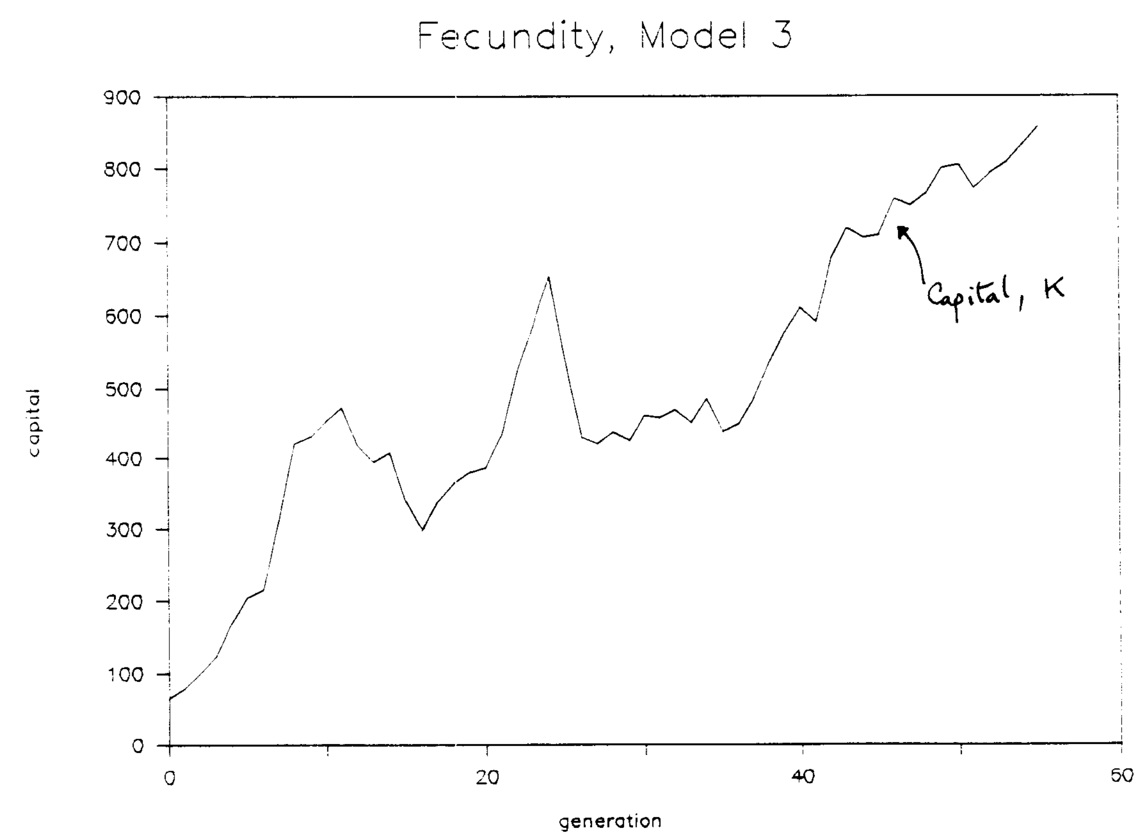
Every 25 years person gives birth to Γ_i children, $0 \leq \Gamma_i \leq 6$. The Γ_i of the offspring is the Γ_i of the parent plus random (-0.5, 0.0, 0.5). The chance of each child surviving is indexed by

$$z = 1 - h(\mu_0 + \mu_1/(C_{it} - \hat{c}))$$

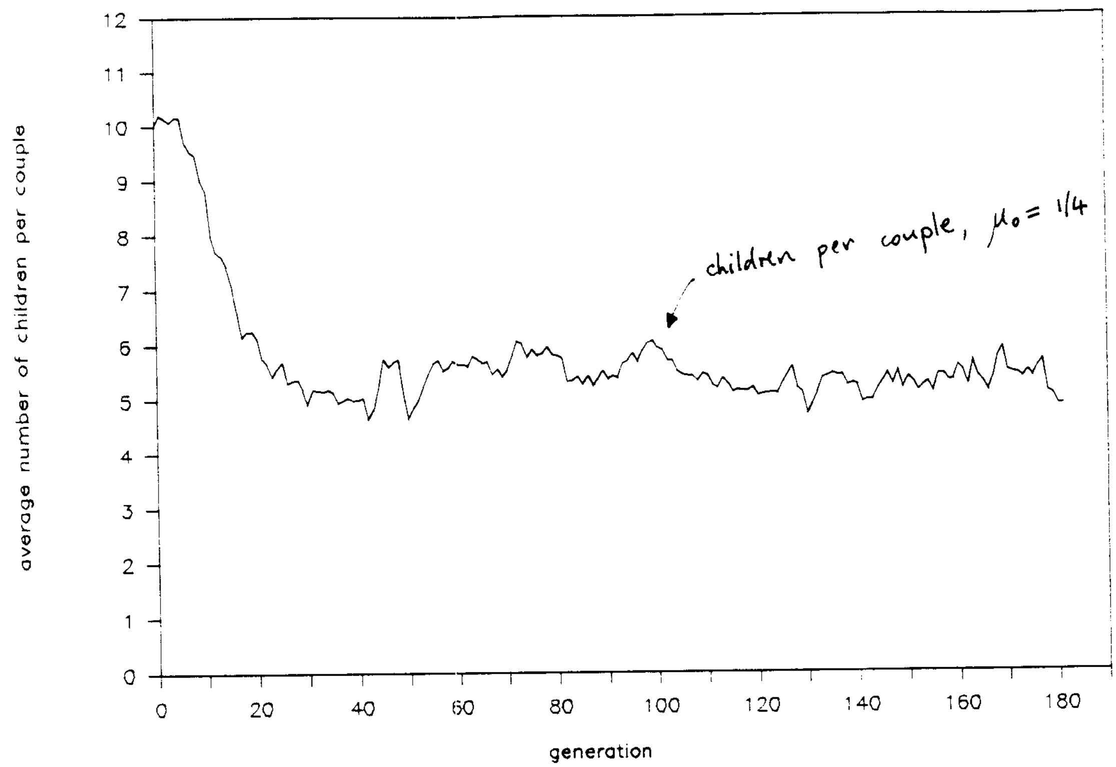
If $z < 0.5$ then the offspring dies before reaching maturity. Assets are equally distributed between surviving offspring. If no offspring survive the parent consumes all their assets in a final splurge.

The number of surviving children someone leaves thus depends on their fecundity Γ_i and their consumption C_{it}. The larger is μ_0 the greater is the background level of mortality of children which is independent of consumption levels.

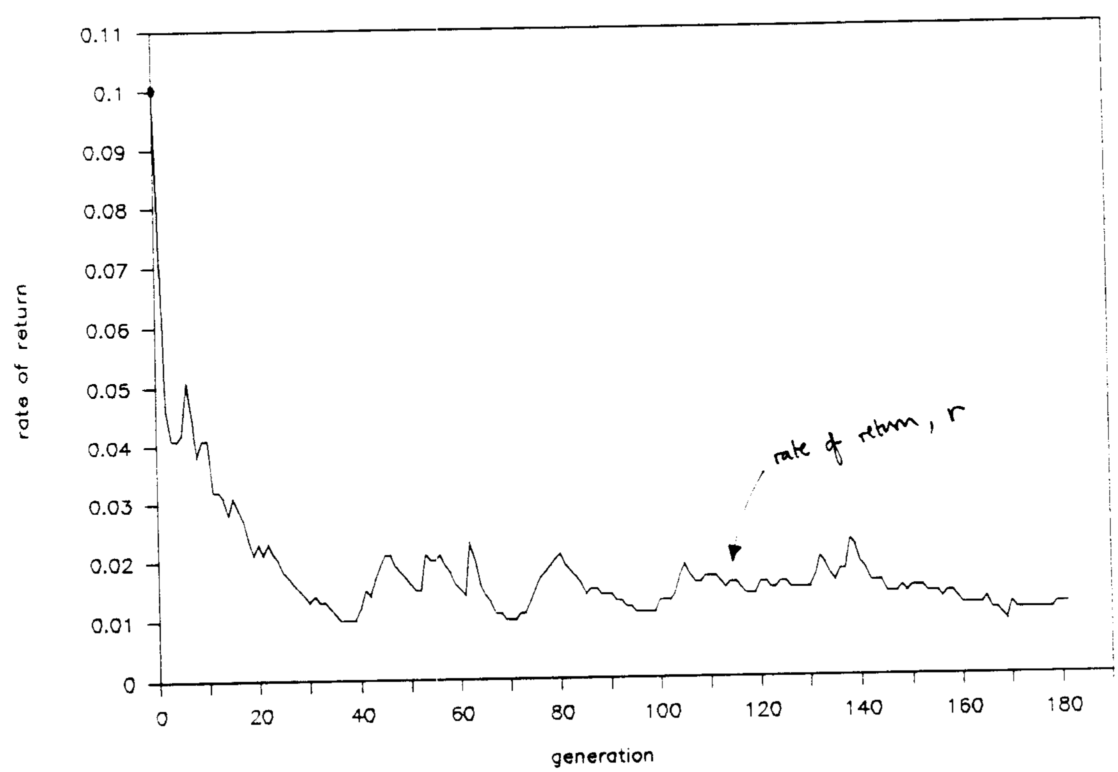

Fecundity, Model 3
rate of return, fecundity index
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
generation
Probability of only 1 child, εi
rate of return, r


Fecundity, Model 3
capital
900
800
700
600
500
400
300
200
100
0
0
20
40
50
generation
Capital, K

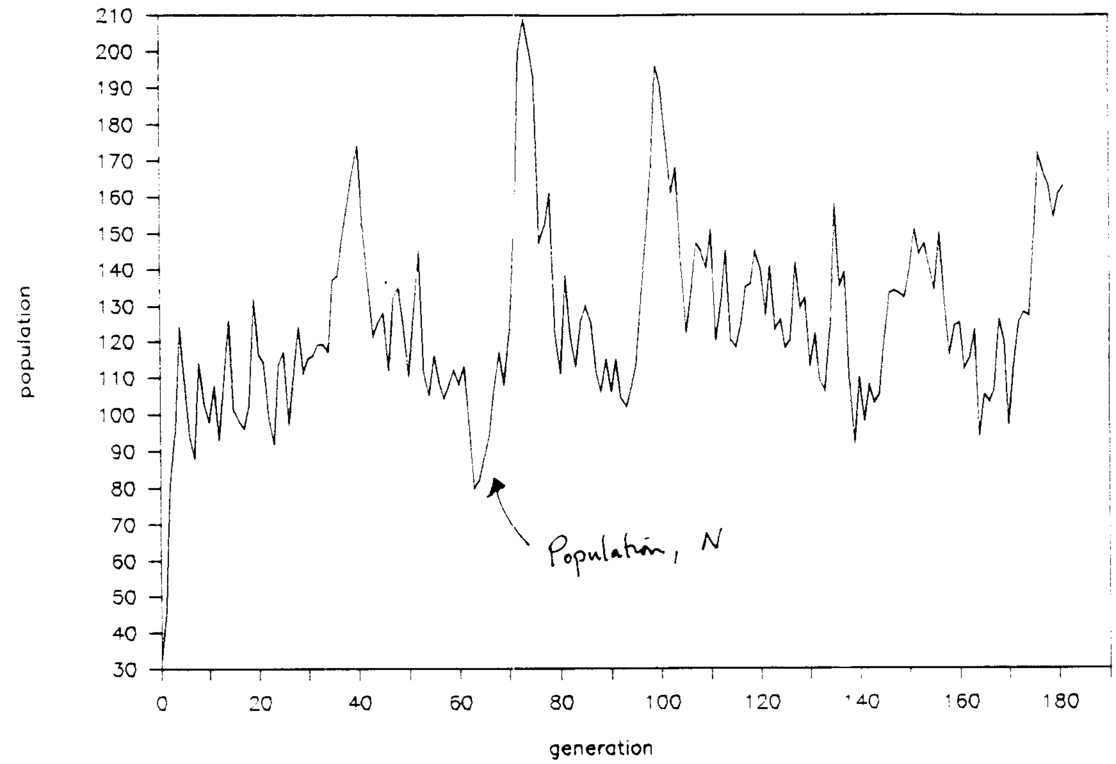
Model 4, Fecundity



Model 4,



Model 4,



Model 4,