mining the long-term behavior modes of World3 is the fact that FCAOR *must* rise toward 1.0 as resources near depletion.

The exact shape of the FCAOR curve, the assumed initial value of nonrenewable resources NRI, and the rate of growth of resource consumption are the three major determinants of the time remaining before rising resource costs interfere with the growth of industrial capital. Of these three determinants, the rate of growth of consumption (resulting from the rate of growth of population POP and of industrial output per capita IOPC) is by far the most important, as will be demonstrated in section 5.6 and in Chapter 7. If resource usage continues to increase at rates approximating the long-term trend of 4 percent per year, a relatively large error in the estimation of NRI or FCAOR will cause only a small error in the timing of the eventual increase in resource costs.

In the formulation of the FCAOR relationship, the assumption that FCAOR will remain constant at a low value as resources are depleted to half their initial value implies significant future advances in exploration and extraction technologies. To test the effects of technological advances beyond those included in the model, one can imagine the two forms of FCAOR shown in Figure 5-23. The solid line represents the standard FCAOR curve, which assumes improvements in exploration and extraction technologies as a part of current trends; the broken line assumes advances in exploration and extraction technologies beyond those included in the standard FCAOR relationship.

As can be seen in Figure 5-23, substantial improvements in technology enable FCAOR to remain at a low value for a larger fraction of the lifetime of resources. However, as the fraction of resources remaining NRFR approaches zero, the fraction of capital that must be allocated to obtaining resources must increase to 1.0.

The next section tests the sensitivity of the behavior of the nonrenewable resource sector to changes in the FCAOR relationship, the initial value of nonrenewable resources NRI, and the growth of the nonrenewable resource usage rate NRUR.

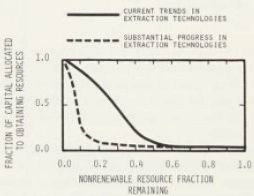

Figure 5-23 The effects of additional advances in extraction technologies on the fraction of capital that must be allocated to obtaining resources

5.6 SIMULATION RUNS

To illustrate the behavior of the nonrenewable resource sector, it was simulated alone, using simplified assumptions about inputs from the rest of the model. The equations governing the investment and depreciation rates of industrial capital (described in Chapter 3) were added to the resource sector to complete the sector's single negative feedback loop. The structure used for the simulations in this section is shown in Figure 5-24.

Since, in these simulations, we wished to focus on the single negative feedback loop relating resource depletion and industrial activity, it was assumed for these runs that the world population grows at a constant 1.2 percent per year and that its growth will not be affected by developments in the nonrenewable resource sector. The feedback interaction of the nonrenewable resource sector with the population sector is discussed in the simulations of World3 in its entirety (Chapter 7). The reinvestment fraction of industrial output was assumed to be constant at 33 percent; the average life of industrial capital ALIC was assumed to be 14 years (see Chapter 3).

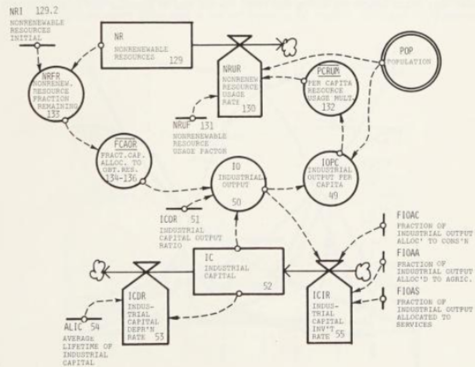

Figure 5-24 DYNAMO flow diagram for the nonrenewable resource sector simulation runs