resources FCAOR. Because industrial output IO is growing at a faster rate than population POP, industrial output per capita IOPC increases steadily during this period. As a result, per capita resource usage also increases. When combined with a growing population, the net growth in the resource usage rate amounts to about 4 percent per year.

Column 6 of Figure 5-1 gives the projected rates of growth in several mineral and fossil-fuel resources. The exponential resource index, or the length of time that resources would remain available under conditions of exponentially growing usage rates, is given in column 7. This index illustrates the dominant role of exponentially growing usage rates in the resource system. Continued exponential growth in usage makes the static resource index wholly inaccurate; Figure 5-27 illustrates the relationship between the static resource index and the exponential resource index for various rates of growth. The graph indicates that as long as usage is growing exponentially, even at low rates of growth, there is a drastic reduction in the potential lifetime of the resource. The amount of this reduction depends more on the fact that the growth is exponential than on the precise rate of increase. Reducing the rate of increase from 4 percent to 3 percent has very little effect on the potential lifetime of a given resource. The dominance of exponential growth is the cause of the insensitivity of the sector's behavior to errors in estimates of the initial value of nonrenewable resources NRI, as illustrated by Run 5-2 (Figure 5-26).

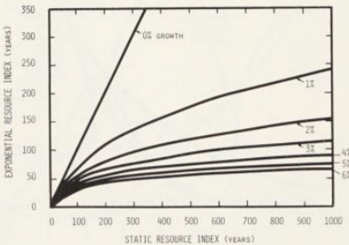

Figure 5-27 Exponential versus static resource indices as a function of annual growth rates

The effect of cost-reducing extraction technologies on the fraction of capital allocated to obtain resources FCAOR has also been discussed. The standard run, Run 5-1, was simulated with a form of the FCAOR relationship equivalent to the solid line in Figure 5-23. The broken line in Figure 5-23 illustrates a form of FCAOR that would reflect significant new technological advances that lower the costs of resource processing. A simulation of the resource sector with the latter form of FCAOR yields the behavior shown in Run 5-3 (Figure 5-28). The major effect of this change is to postpone the decline in industrial output IO for a few years and then to precipitate a rapid decline in IO, as opposed to the more gradual decline shown in Run 5-1. This result is due to the ability of advancing technologies to offset the inherent effects of resource depletion (such as declining grades and deposits) temporarily, thus encouraging resource utilization in the short run. In the long run, when the effects of depletion finally are manifested in higher resource costs, the FCAOR curve climbs so steeply that the system has little time to adjust.

To the extent that the model assumptions reflect the real-world resource system, technologies that maintain low costs in the resource industries without simultaneously discouraging an exponential usage of resources appear to be counterproductive in the long run. Technologies that lower the cost of mining virgin minerals tend to eliminate the economic incentive to look for more abundant substitutes or to increase recycling.

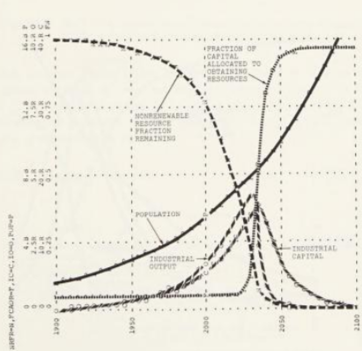

Figure 5-28 Run 5-3: The effects of cost-reducing technologies on the behavior of the nonrenewable resource sector