

allocated to mining remained minimal, at levels that were never a significant hindrance to the industrial process. For these reasons, we assumed that FCAOR remains at a minimal value of 5 percent of total capital in the world model as NRFR decreases from 1.0 to 0.9 from 1900 to 1970.

To estimate the behavior of FCAOR as the total stock of resources is depleted beyond this historical period, one can examine the pattern of costs of individual resources in geographic areas where those resources are nearing depletion. Crude oil and natural gas reserves in the continental United States are significant examples: the total reserves of both resources have been depleted to less than half their estimated initial reserves by 1970 (CRAM 1969).

In the case of U.S. oil, Figure 5-3 illustrates the number of barrels of oil obtained per foot of well drilled as a function of the cumulative number of feet drilled. Because the capital costs per foot drilled have been either constant or rising (Energy Study Group 1965), the capital cost per barrel discovered has been rising. Using an estimate of 10 dollars per foot drilled for the drilling cost (Energy Study Group 1965, p. 149) and an estimate of 165×10^9 barrels as the total initial supply of oil resources in the continental United States (CRAM 1969, p. 183), it is possible to plot the relationship between the cost per barrel and the fraction of U.S. oil remaining as shown in Figure 5-21, where rising unit discovery costs are clearly in evidence. A similar relationship has been derived for the discovery cost per cubic foot of U.S. natural gas versus the fraction of natural gas resources remaining (see Figure 5-22).

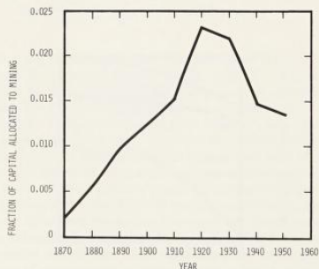


Figure 5-20 Fraction of capital allocated to obtaining mineral resources in the United States, 1870-1950

Source: Data derived from Barnett and Morse 1963, p. 220.

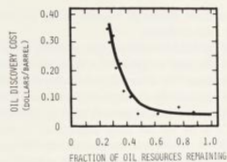


Figure 5-21 The cost of U.S. oil exploration as a function of the fraction of oil resources remaining, 1910-1965

Source: Data derived from CRAM 1969, p. 186.

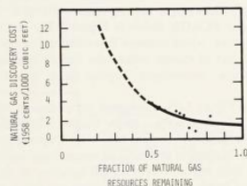


Figure 5-22 The cost of exploration for U.S. natural gas as a function of the fraction of natural gas resources remaining, 1944-1963

Sources: Data derived in Naill 1973 (from cost and discovery data in API 1967 and AGA 1970).

Figures 5-21 and 5-22 show significant cost rises as the fraction of resources remaining NRFR drops below half the estimate of initial resources. Thus we assumed in World3 that the progress of technology will continue to offset the effects of resource depletion until half the initial resources are depleted. At that point, resource costs, represented by the fraction of capital allocated to obtaining resources FCAOR, begin to rise (Figure 5-18).

It is important to note how tenuous this assumption may be. The depletion of oil and natural gas resources in the United States may be no more than significant exceptions to the general behavior of most nonrenewable resources as they undergo depletion. Certainly, much research concerning the long-term effects of resource depletion is needed to obtain a better estimate of this relationship. However, for the purposes of the model, the only significant characteristic of the relationship in deter-