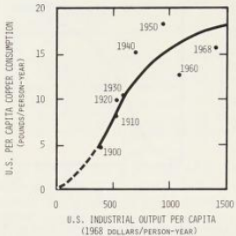

Figure 5-16 Per capita copper consumption in the United States as a function of industrial output per capita, 1900–1968
Source: Copper consumption from AMM 1970; IOPC derived from GNP data in U.S.D.C. 1969.

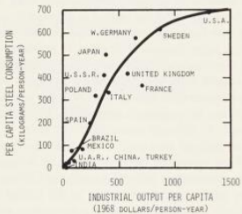

Figure 5-17 Per capita steel consumption as a function of industrial output per capita, selected countries, 1970
Source: Steel consumption from U.N. 1970; IOPC derived from GNP data in *WBA* 1970.

demand for resources would increase beyond that assumed in the present model as industrialization proceeds, which would be a less conservative assumption than that made in World3.

The numerical values used in the per capita resource usage multiplier relationship PCRUMT in the world model were obtained from Figures 5-15, 5-16, and 5-17 in the following manner: if we take 220 dollars per person-year as the world average industrial output per capita IOPC in 1970 (see Chapter 3), then the point on the curve at which PCRUM represents usage normalized at its 1970 level would be at approximately 100 kilograms per person-year for steel (Figure 5-17). As IOPC increases, per capita steel consumption tends to level off at a value of 700 kilograms per person-year, seven times its value at the 1970 level of IOPC. A similar trend is exhibited for copper: per capita copper consumption levels off at about seven times its value at the 1970 level of IOPC—220 dollars per person-year. The relationship for PCRUM has been drawn to reflect these trends with per capita consumption reaching a constant level at seven times its reference level when IOPC is approximately six times its 1970 world average level of 220 dollars per person-year. These numbers express only order-of-magnitude estimates of the expected demand for resources as industrialization proceeds.

The S-shaped curve of per capita resource usage PCRUM shown in Figure 5-14 is included in the world model simply as an indication of apparent real-world trends. The curve represents hypotheses about human values and about technology, both of which could change in the future. The relationship can be altered at any time in the model simulation to test the effects of significant system changes (such as the increased recycling of resources) that would increase or decrease the amount of nonrenewable resources NR each person consumes. A change in per capita resource usage can be accomplished in the present model in two ways: first, by changing the nonrenewable resource utilization factor NRUF from its normal value of 1.0, it is assumed that resource conservation reduces per capita consumption equally at all levels of industrial output per capita IOPC and thus does not change the general S-shaped characteristics of the PCRUM relationship; second, other hypotheses of the behavior of per capita resource usage as a function of IOPC (such as a continually increasing relationship, discussed earlier) can be tested by changing the PCRUM relationship directly.

Nonrenewable Resource Fraction Remaining NRFR

```
NRFR.K=NR.K/NRI                                          133, A
   NRFR    - NONRENEWABLE RESOURCE FRACTION REMAINING
               (DIMENSIONLESS)
   NR      - NONRENEWABLE RESOURCES (RESOURCE UNITS)
   NRI     - NONRENEWABLE RESOURCES INITIAL (RESOURCE
               UNITS)
```

The nonrenewable resource fraction remaining NRFR is simply the fractional amount of resources that has not been exploited. It was calculated by dividing the current level of nonrenewable resources NR by the initial level of resources NRI. This fraction is used to determine resource costs, measured by the fraction of capital allocated to obtaining resources FCAOR. The value of NRFR in 1970 is 0.9.

Fraction of Capital Allocated to Obtaining Resources FCAOR

```
FCAOR.K=CLIP(FCAOR2.K,FCAOR1.K,TIME.K,PYEAR)             134, A
   FCAOR  - FRACTION OF CAPITAL ALLOCATED TO OBTAINING
              RESOURCES (DIMENSIONLESS)
   CLIP   - A FUNCTION SWITCHED DURING THE RUN
   FCAOR2 - FCAOR, VALUE AFTER TIME=PYEAR
              (DIMENSIONLESS)
```