The delays between the initial decision to develop new technologies and their final implementation cause technological improvements to continue to increase even after industrial output begins to decrease, making the decline in industrial output per capita IOPC more severe than in Run 7-21. However, the additional technological developments in resource recycling lead to a higher nonrenewable resource fraction remaining NRFR in the year 2100 in Run 7-22 than in Run 7-21. Although the insertion of a 10-year technological delay makes the behavior of food per capita FPC unstable, food per capita FPC is higher in Run 7-22 over the long run because of higher land yields. The index of persistent pollution PPOLX declines to a lower value in Run 7-22 than in Run 7-21. Like the other delays in the model, delays in technological development and implementation increase the tendency of the system toward an unstable behavior mode of overshoot and decline. Because of these delays, the decline in industrial output per capita IOPC in Run 7-22 is more precipitous than that observed in Run 7-21.

Both runs show that the adaptive technological policies are successful in achieving their goals: nonrenewable resource usage, pollution generation, and food per capita are all kept near their desired levels through the development of new technologies. However, the assumed value system of the modeled society causes it to maintain its standards for food, pollution, and resource use even at the sacrifice of some industrial output. Eventually, the costs of developing and implementing the new technologies required to maintain these standards force industrial output per capita to decline. The next run tests the behavior of the model under the assumption that a decline in industrial output per capita is too high a price for society to pay for the implementation of new technologies. Technological policies will be initiated only if they do not interfere with the growth in industrial output per capita.

Adaptive Technological Policies—The Effects of Delays and Costs, with a Bias for Continued Growth in Industrial Output per Capita IOPC The previous run assumed that advances in recycling, pollution control, and land yield technologies can be obtained with increasing capital costs, and only after a 10-year technological development and implementation delay. Run 7-23 (Figure 7-32) shows the behavior of the model if these assumptions are augmented with an assumption of a bias toward continued growth in industrial output per capita IOPC. This additional assumption implies that new policies of technological development will be initiated only as long as they do not hamper the growth in industrial output per capita IOPC, as perceived by a year-to-year growth index.

Figure 7-33 shows the structural additions assumed for this run. As in the previous run, improvements in technology decrease nonrenewable resource usage, decrease pollution, and increase land yields after a delay. These technological improvements also raise the industrial capital-output ratio, which tends to decrease industrial output per capita IOPC. In this run, however, if the growth rate of IOPC

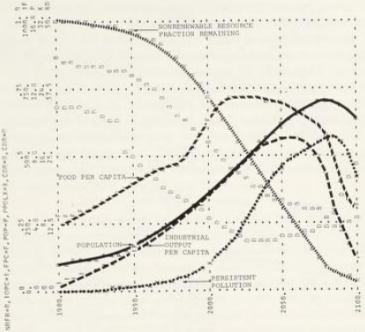

Figure 7-32 Run 7-23: adaptive technological policies—the effects of delays and costs, with a bias for continued growth in industrial output per capita

The previous run assumed that new recycling, pollution control, and land yield technologies are developed in response to a perceived need for them. Because of the time involved in technological development and implementation, however, these new technologies were effective only after a delay. Moreover, their development and implementation required additional capital, which increased the industrial capital-output ratio. In this run, the assumptions of Run 7-22 are augmented with a societal bias toward continued growth in industrial output per capita IOPC. Technological policies are implemented only as long as they do not hamper continued growth in IOPC. This policy is effective in continuing growth in the short run but counterproductive in the long run: the failure to implement the new technologies causes a significant depletion of resources and growth is ultimately terminated.

decreases, the initiation of new technologies is also decreased. If the growth in IOPC declines to zero, no new technological improvements are initiated.

Run 7-23 shows that the adaptive technological policies are successful in keeping resource usage, pollution, and food per capita near their desired levels until the year 2000, when they begin to interfere with the growth in industrial output per capita IOPC. To maintain continued growth in industrial output per capita, fewer new technologies are initiated after the year 2000, for society is not willing to pay their costs in terms of an increase in the capital-output ratio. The decrease in new land yield technologies causes the growth in food per capita to stop shortly after the year 2000. The index of persistent pollution PPOLX remains higher in Run 7-23 than in