4. Another delay, to allow for testing, social acceptance, and implementation of the new technology. The length of this delay will depend on the magnitude of the required departure from the present way of doing things.
5. A larger impact of the technology on the total system, including social, energy, and environmental costs in areas widely separated from the actual point of implementation.

Nearly every causal relationship in World3 could conceivably be changed by some sort of new technology. In the past, various technologies have directly or indirectly improved birth-control effectiveness, increased food production, and provided better techniques for abating pollutants. They have also increased life expectancy through medical advances, hastened the rate of land erosion, and developed more toxic pollutants. It is by no means certain that technologies will continue to do any of these things in the future, for the human values and economic institutions that govern technological development are always subject to change.

Since so many causal relationships can be altered by conceivable technological changes, we had to consider building technological change directly into each model relationship as we formulated it. We did that by assigning possible technologies to three categories: already feasible and institutionalized, feasible but not institutionalized, and not yet feasible.

Some causal relationships have historically been influenced by technology and continue to be so influenced today. They occur whenever social agreement is reached about the desirability of change and when resources and institutions to bring about that change are already integral parts of the system. Some examples are medical technology to improve health, industrial technology to raise production efficiency, agricultural technology to increase land yields, birth-control technology to control family size, and mining technology to discover and exploit lower-grade nonrenewable resources. A significant number of the world's people have adopted a value system that will continue to promote these technologies as long as their costs can be afforded. They are effectively built into the world's socioeconomic system. Therefore, they are also built into the relationships of World3, with the assumption that they will continue to develop and spread through the world, without delay, as long as economic support for them continues.

Other technologies have not been so widely accepted that they can be considered functioning parts of the world system. It is not clear that all the nations of the world will be willing to institutionalize and pay for such technologies as pollution control, resource recycling, the capture of solar energy, supersonic transports, fast-breeder reactors, or increased durability of manufactured goods. All these technologies are feasible, but it is not possible to state with confidence when or whether any of them will be adopted on a worldwide scale. Therefore, we incorporated many of them as optional functions that anyone analyzing World3 can activate at any specified time in the model run. The model can thus be used to test the possible impact of any or all of these technologies and the relative advantages or disadvantages of adopting them.

One set of technologies was omitted from the model—discoveries that we cannot possibly envision from our perspective in time. No model, mental or formal, can incorporate unimaginable future technologies as they may actually occur. That is one reason why no model can accurately predict the future. Any long-term model that is being used to aid the policy-making process must be updated constantly to incorporate surprising new discoveries as they are made and to assess how they may change the options of human society.

It would have been possible to include in World3 the assumption that some unimaginable discovery will come along in time to solve every human problem. Many mental and formal models seem to be based on that assumption,* and its effect on the model's behavior is illustrated in Chapter 7 (section 7.5). But our own bias as modelers and as managers has been to search for policies based on the realistic constraints and potentials of the system as they appear at the moment, rather than to rely on developments that may or may not occur in the future.

We have already mentioned that both technology and price are dynamic elements that depend directly on the values of human society. Values also influence many other dynamic elements of interest in a model of physical and demographic growth. Therefore, although World3 was not designed to depict the dynamics of social value change, the model had to contain some assumptions about human goals as they influence and are influenced by the processes of physical growth.

In the difficult task of modeling human values we tried to include only the most basic values that can be regarded as globally ubiquitous. They begin with requirements for survival—food, water, shelter—and go on to include a hierarchy of other desires—longevity, children, material goods, and social services such as education. Some of these values (for example, desired family size and preferences among food, material goods, and services) are represented explicitly in the model as variables that have an important influence on economic decisions. Others are included implicitly, as in the allocation of service output to health services or in the quantity of nonrenewable resources used per capita.

All the values included in World3 are assumed to be responsive to the actual physical and economic condition of the system; thus they are all involved in feedback loops. The patterns of dynamic value change included in the model, however, were limited to the patterns of change historically observed over the last hundred years or so. During that time, the major global force behind value change has been the process of industrialization, a process that is still under way in most nations of the world. Therefore, the values that both shape and respond to the development of the model system follow the historical patterns observed during industrialization. As industrialization increases in the model—measured by the level of industrial output per capita—the aggregate social demand shifts in emphasis from food to material goods and finally to services. Changes also occur in the emphasis placed on obtaining children, education, and health care and in the distribution of various goods and services throughout the industrializing economy.

We did not build into World3 any global shifts in values other than those that might be expected to take place as the world becomes more industrialized. It is possible that new value systems will evolve, but the pace of value change is always slow and the precise nature of new social attitudes is currently more a matter for

*For examples, see Boyd 1972, Oerlemans et al. 1972, and Cole et al. 1973.