ESSAY

Of ladders, cycles and economic growth

by Ralph Gomory

A major scientific advance is at last achieved. Engineers refine it through successive stages until it can be embodied in a useful new device. This is the "ladder paradigm" for the evolution of technology into product. If the ladder paradigm sounds familiar, it should; it dominates our view of the relation between science and manufacturing. Yet technology can also reach the marketplace as an incremental improvement, introduced as one generation of a product succeeds another. This is the obscure "cycle paradigm." Simple? A small distinction? Perhaps. And yet by failing to make it, managers and policymakers commit strategic errors that hurt the competitiveness of U.S. firms.

The ladder paradigm shapes our thinking because it makes both good history and good journalism. Bell, the Wright brothers—their careers give the pattern substance. During World War II radar and the science-led, science-developed process of creating the atomic bomb reinforced the concept. The transistor stands as a more recent example. It was the result of decades of fundamental scientific research that eventually yielded a practical device. A series of rapid developments then led to the manufacture of the first chips and to the foundation of a major new industry.

The ladder paradigm describes the start-up of an industry or the launch of a product. The cycle paradigm provides the right approach to planning the evolution of an existing product. It mandates repeated, incremental improvement in each generation. By implementing the cyclic process, manufacturers have been able to pack an increasing number of components in a square centimeter, so that today a chip can contain several million elements. Such achievements make good computers but not good mythology.

That is unfortunate because the cycle paradigm has implicit in it several realities that are dangerous to ignore but powerful if recognized and exploited. First of all, the length of the cycle is very important. Suppose two companies having access to the same technology are manufacturing a product, one product generation after another. One company can bring the product from design to market in three and a half years. The other can do it in two years. Presume further that both products reach the market in 1990. Clearly, the technology embedded in the product with the shorter cycle will be more advanced, providing a competitive lead, even though both companies have access to the same technology. A short cycle time has another advantage: it permits faster response to changing market conditions.

The cycle paradigm demands discipline. It does not welcome lightning strokes of creativity. A new idea has to be well developed, and it has to be presented at the right time, not part way through a cycle. Consequently, the cyclic process often seems resistant to outside ideas. This frequently accounts for charges of insularity and jeers that play on the "not invented here syndrome."

A look at Japanese manufacturers shows that they are fully aware of the realities that the cycle paradigm dictates. They design a product so that it can be easily made. In fact, design and manufacturing teams often work together. Japanese manufacturers have achieved very short cycles, and they carefully time the introduction of new technology.

Yet our perception, distorted by the ladder paradigm, misreads the situation. The press, for example, tends to emphasize the advanced-technology programs that Japan's Ministry of International Trade and Industry sponsors. Such programs are useful in the early stages of development. But it is the successful execution of cycle strategies, not ladder strategies, that has created the deciding Japanese margin in such industries as automobiles, semiconductors and consumer electronics.

What we do not know can indeed hurt us, in several ways. It can cripple the formulation of adequate public policy. High-temperature superconductivity illustrates the point. At least 10 years will pass before such technologies can become economically significant. It seems plausible that applications capable of transforming society and the economy in major ways lie even farther in the future. During this time knowledge inevitably diffuses throughout the world, so the advantage gained from discovering the phenomenon is lost. Yet when this undoubtedly great scientific achievement was announced, meetings were called in Washington that the president attended, Congress enacted legislation and committees were set up to advise the government. All of this activity assumed a close tie between basic discovery and industrial supremacy, which unfortunately does not exist.

High-definition television has evoked the same response from policymakers. Yet it would be more useful to look at this technology as part of the continuum of TV products. The question is not whether to get into HDTV, it is whether to get back into making television sets. The misperception has its roots in the confusion between ladders and cycles. The only way that you can enter HDTV is to build a major manufacturing capability, back it with a strong R&D program and start the cycle churning. R&D alone will not do it. The market for TV devices does not invite entry from the outside with a new technology. It is an ongoing market, not a new one.

The ladder paradigm distorts the national view in other ways. Take investment in R&D. We note aggressive Japanese action in this area and assume that the appropriate response is to mimic our rivals. Again the picture is "you put R&D in here, and the product pops out there." That's a very different picture from the one you actually encounter if you are developing products cyclically. In cyclic development the income from sales of the product funds both current expenses and R&D for the next product generation. A fixed fraction of this stream, as much as 8 to 10 percent, would be committed to R&D. In this cyclic world a successful product generates more R&D, an unsuccessful product less. It is not easy to persuade managers to find money from other sources to bolster R&D for a losing product.

A high dollar level of R&D can create a successful product. Such high levels can also be the consequence of product success. Yet if we think "ladder," we will automatically ascribe a competitor's success to intense R&D and respond in the same manner. Such a response overlooks the fact that in the cyclic world R&D is not an independent variable.

The paradigms of ladder and cycle are not incompatible. Companies need a mix of new and mature products. In our thinking we need to understand the cycle as well as the ladder paradigm so that we can excel at applying either strategy. As long as we ignore these realities, the U.S. economy's ability to compete and grow will suffer.

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