

The solid corporation acquires suppliers along with technology.

Manufacturing: The New Case for Vertical Integration

by TED KUMPE and PIET T. BOLWIJN

Ever since Robert Hayes and the late William Abernathy exposed the ways we manage our companies into decline, executives in big manufacturing corporations have been struggling with a central strategic problem.¹ It is to find the right balance between investing in vertical integration and encouraging process technology development among suppliers.

The problem for managers is "not their reluctance to take action and make investments," Hayes and Abernathy observed, "but that, when they do so, their action has the unintended result of reinforcing the status quo. In deciding to integrate backward because of apparent short-term rewards, managers often restrict their ability to strike out in innovative directions in the future."

By "innovative directions," Hayes and Abernathy meant strategic approaches that absorb into the production chain the most technologically advanced and cost-effective ways of making components. For any manufacturer, they conceded, backward integration eliminates some purchasing and marketing functions, centralizes overhead, and allows the pooling of R&D and design efforts; where components are, in effect, commodi-

ties (ferrous metals or petroleum, for example), backward integration almost certainly boosts profits. Nevertheless, for a technologically active company—one that makes sophisticated consumer electronics or durables—they saw a serious risk. Indeed, Hayes and Abernathy suggested that such a company's best course would be to bid for individual components, not for other businesses.

"[Managers] may suddenly discover that their decision to make rather than buy important parts has locked their companies into an outdated technology." They may find themselves "shut off from the R&D efforts of various independent suppliers by becoming their competitor." Moreover, when a company commits its time and resources to master technology back up the channel of supply, it may be distracted from doing its job well. "Long-term contracts and long-term relationships with suppliers can

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1. Robert H. Hayes and William J. Abernathy, "Managing Our Way to Economic Decline," HBR July-August 1980, p. 67.



"Nice to meet you, Benson. Any friend of free market forces is a friend of mine."

achieve many of the same cost benefits as backward integration without calling into question a company's ability to innovate or respond to innovation."

The further development of computer-driven manufacturing systems during the years since Hayes and Abernathy issued their warning has certainly vindicated a part of their argument—the part that emphasizes the revolutionary benefits of technology. We know a good deal about what it takes to absorb advanced manufacturing systems into the plant—more precisely, how they transform the plant; we know how expensive and taxing automation can be.

General Electric has been working for five years to transform its Appliance Park complex in Louisville, Kentucky (where it builds dishwashers, washers and dryers, refrigerators, and electric ranges) into a highly automated operation. Islands of automation introduced at the dishwasher facility in 1983 have slashed cycle times from five days to several hours, and have helped GE boost market share from 30% to more than 40%. The new refrigerator line, on which \$100 million was spent, is automated from one end of the plant to the other. All told, output at Appliance Park has increased while employment has declined from 19,000 to 10,000 over the past decade. GE managers hardly needed the distractions of running compo-

nents businesses not already their own during this high-stakes transition.

At the same time, Hayes and Abernathy have been proved right about the devolution of important design and R&D functions onto upstream producers. Many smaller suppliers, especially parts makers in the auto industry, have gained skill in computer-aided design and manufacturing systems. Many manufacturers of finished goods have come to depend on innovative suppliers and machine tool vendors to develop robust parts and more efficient manufacturing systems—tasks they used to perform on their own. On the other hand, a good many independent suppliers should now be considered members of the big corporation's family—not owned, but so beholden to the big corporation that their business plans are controlled from above. Is the age of vertical integration over?

We think not. In our view, the solid corporation will continue to view vertical integration as a critical part of manufacturing reform. No doubt, major manufacturers have to learn to get the most from suppliers. But manufacturing reform and backward integration are related in subtle ways to the three stages of production over which the big manufacturers preside. Without integration, technology-based corporations may wind up beggaring upstream components producers—businesses that need the most investment—in order to earn premiums for downstream assembly and distribution operations, businesses that are comparatively flush. This cannot go on indefinitely.

Three Tiers of Production

The advantages of backward integration become clearer when we look closely at the levels of production and at the market forces and advanced technologies shaping each one.

Generally speaking, the production process can be divided into three stages: the assembly stage, the sub-assembly stage, and the component stage; at each there is a separate tier of factories and businesses. Philips' compact disc players, for example, are produced in plants designed to make finished players from subassemblies, typically, a deck—the chassis into which the motor, laser, and other parts have been integrated—a printed circuit board, and so on. More familiar, perhaps, are subassemblies for cars: engines, gearboxes, or brakes.

In most cases, subassemblies are produced at some distance from assembly plants, either by independent companies—that is, original equipment manu-

facturer (OEM) suppliers—or by wholly (or partially) owned subsidiaries. Philips owns 400 factories, several of which produce subassemblies such as picture tubes, motors for VCRs or CD players, and decks for VCRs—not only for Philips but also for some of its competitors. The picture tube factories, for instance, deliver roughly 50% of their turnover to non-Philips customers.

At the base of the production pyramid are the components makers; the component stage is to subassembly what subassembly is to assembly. The components of a compact disc player—molded plastics, chips, resistors, and wires—may come from independent or subsidiary businesses, large or small. A car's components are the balance shafts or pistons incorporated into the engine, or the stamped sheet-metal parts that are welded into unpainted "white-bodies." Philips' component factories produce resistors, capacitors, metalware, semiconductors, plastic parts, and other items. These units also act as suppliers for customers both inside and outside the company.

Advanced manufacturing systems affect each tier of production in a different way so that, at each, the cost of failing to invest in process technology is quite different. Each tier competes to serve a distinct market. Each tier will have special problems with respect to production flexibility and quality control.

Consider, first, the changing strategic and manufacturing priorities of assemblers, the big industrial corporations themselves. During the 1950s, in a world economy characterized by scarcity, price was the most important criterion for any consumer. People were happy to have a radio or car; manufacturers were happy to mass-produce hard goods, most of which now seem terribly primitive, in huge batches along moving assembly lines—and with the cheapest labor possible. During the 1970s, following the sharp rise in prosperity, quality became as important for consumers as price. Increasingly, consumers are demanding quality products more nearly tailored to individual needs and tastes—products for young professionals, families, and retirees.

And so corporations like Philips need to be particularly good at manufacturing flexibility, the production of customized products aimed at market niches. To compete effectively in world markets we must differentiate our product lines from the start, without sacrificing quality or price. In the middle of the game we must be flexible enough to increase volume sharply for segments in which demand proves high. Finally, we must redesign our products relentlessly, so they do not outstay their welcome.

Just look at audio/video products, whose commercial life cycles have dropped to a year, in some cases even less. Philips produced about 100 different color television models in 1972. At present, its product line worldwide includes more than 500 different models. As for CD players, Philips puts a new generation on the market almost every year, and each generation offers a jump forward in styling and technology. Philips produced 10 types of players in 1982, 150 today. Manufacturing corporations that do not work to shorten product life cycles in this way will almost certainly be leapfrogged by the competition.

How Assemblers Do Well

And so new marketing pressures and technological advances are causing Philips to rethink its investment priorities. What kind of manufacturing strategy is right for assemblers? In the short run, it is probably not a good idea to invest heavily in advanced flexible manufacturing systems—not yet. Managers still cannot buy robots that are both flexible and inexpensive enough to handle major design changes in end products, whose life cycles are inherently short. It is more sensible for assemblers to divide a plant into focused factories within factories; more cost-effective to pay motivated people and pay for more or less dedicated machines—machines that are flexible enough to handle design variations in one generation of compact discs or VCRs and that can then be retooled or even discarded when the new generation is born.² In the Wetzlar factory, Philips builds car radios with a modular assembly system in which each standard module performs only a limited number of assembly tasks. Resetting the system for a new generation of radios has thus far proved a simple operation.

The key flexibility for assemblers in the longer run is the setup time required to move from one generation of products to the next. When delivering products quickly and reacting to changing market demands by shortening product cycles, economies of scale are, of course, not worth pursuing. More important efficiencies can be gained from reductions in work-in-progress inventories, stock inventories, throughput time, and transportation costs.

These considerations make it more attractive than ever to set up assembly factories close to end markets. They make the introduction of just-in-time operations necessary. As a matter of fact, industrial corporations add value (and realize high profit margins) less by refining the process of assembly than

2. For an advocacy of this viewpoint, see Richard J. Schonberger, "Frugal Manufacturing," HBR September-October 1987, p. 95.

by marketing aggressively, distributing shrewdly, and backing up their retail customers with fast delivery, satisfactory service, and appealing design.

There are exceptions, to be sure. Where the market is stable (and competition from the Japanese unlikely), a big manufacturer may well justify a long-term investment in automation at assembly. GE's refrigerator market is a case in point. Still, most hard-goods producers do not have the luxury of planning this far ahead. For most of us, the secret of assembly is flexibility, and the secret of flexible assembly is the organization of rather simple machines with people—those most complex and flexible of beings. When you think about it, Volvo's advances in the work team concept may have done more to teach big manufacturers about our "factories of the future" than GE's advances with automation.³

The Philips vacuum cleaner plant at Hoogeveen, Holland recently went through a reorganization to simplify product flow, make the managerial organization leaner and flatter, and institute fast information feedback loops including specialists from development, engineering, production, and marketing. Ideally, the management of assembly will be visible and vigorous. Reporting relationships will be cooperative rather than authoritarian. Assembly systems will ensure rapid communications and feedback of information throughout the organization. Simple, clear-cut, product-oriented organization will break down barriers among design engineers, manufacturing executives, and marketing specialists. Flexibility and bureaucracy do not mix.

None of this is to deny that robotics will likely advance us to the point where assemblers—those that have perfected flow operations—can replace people. Then, automation will mean even more consistent quality at assembly and fewer interruptions on the line; computer-driven refinements in measuring and calibration are already reducing the time operators need to stop the line to reset machines or log in quality control data. Nevertheless, important advances in quality at assembly nowadays are coming not from the architecture of chips so much as from the organization of people, from people-integrated manufacturing, not from computer-integrated manufacturing.

Subassemblies, Components, Quality

The question of quality, of how major manufacturers build it in at assembly, brings us to new and decisive relations among the three tiers of production. It

also brings us to the heart of the matter. That a motivated and well-organized work force is important for assembling quality products is hardly arguable. The most important advances in quality, however, are coming not from anything assemblers do in their factories but from what subassemblers do in theirs.

During the past five years, hard-goods industries have achieved a striking reduction in the number of parts and subassemblies that have to be fit together to make an end product. It is this reduction that, more than anything else, accounts for increasing product quality. Philips, the world's largest manufacturer of compact disc players, has reduced the number of subassemblies by 75% over the last five years. The most prescient manufacturing corporations have been working with OEM suppliers to design subassemblies that are more manufacturable—that include more functions but fewer components and are designed to fit together in more predictable ways. Fewer parts mean fewer opportunities for error.

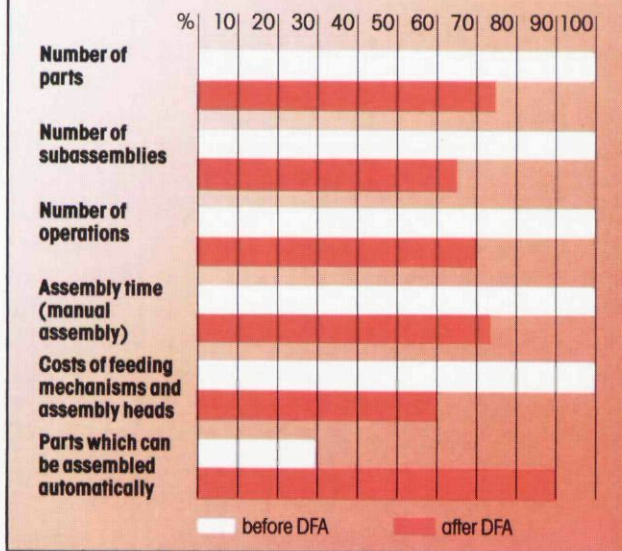
Perhaps the best known of these product programs is the IBM Proprinter, most of whose resilient molded parts snap together and require perhaps one-third the number of assembly operations as earlier model printers. The Proprinter's subassemblies are so manufacturable that robots can put them together, while doing the job manually takes only about three minutes. (Revealingly, after building the units for machine assembly, IBM transferred assembly operations from a robotized line in Charlotte, North Carolina to direct-labor lines at its typewriter facility in Lexington, Kentucky.)

Of course, getting the number of subassemblies down has been a terribly expensive proposition. Early on, IBM committed manufacturing engineers to develop subassemblies for the Proprinter, including investments in robotized injection molding machines and fused plastic/metal components. Subassembly businesses generally soak up a comparatively higher investment in automation and R&D than assembly businesses. Philips invested more than \$250 million in a flat, square picture tube for a new generation of color televisions (CTVs).

It should come as no surprise, then, that the logic working on relations between assemblers and subassemblers works also on relations between components producers and subassemblers—only more so. Technology improvements and design innovations that have increased the complexity of electrical products and vehicles have at the same time greatly reduced the complexity of assembling them from components and subassemblies. New generations of semiconductors, integrated plastic and metal parts,

3. We explore this development in "Toward the Factory of the Future," *McKinsey Quarterly*, Spring 1986, p. 40.

Design for Assembly



We have studied 29 products including compact disc players, video cameras, telephones, and portable irons, from 1984 to 1986. In all, there have been striking reductions in the number of components and assembly operations, and corresponding reductions in cost.

ceramics, surface-mounted devices, switches—all these have led to striking efficiencies.

Since 1984, Philips has reduced the number of parts in its compact disc player by 75%. It has simplified VCRs by a parts reduction of 55%, tuners by 45%, and amplifiers by 40%. And the trend has not been restricted to the makers of audio/visual products. Swatch has reduced the number of components in its watches from 150 to 51. Less dramatically, though more significantly perhaps, Ford has reduced the number of components in its average car from 30,000 to 22,000. Similar changes have been made in microwave ovens, personal computers, office copiers, and air compressors.

These reductions have meant improved productivity rates at assembly. They have also meant, clearly, decreased value-added from assembly operations as a whole. For end products, even those that depend almost entirely on direct labor to fit their parts together, final assembly constitutes only a small part of the total labor content. There has been a strong shift in the distribution of value-added toward the components stage. In 1969, assembly of a CTV took 12½ hours; today the process takes approximately 60 minutes, and the elapsed time will go down considerably within the next few years.

At Philips, the cost structure of consumer electronic products—CDs, CTVs, PCs, or word pro-

cessors—typically consists of 70% material, 5% direct labor, and 25% other costs like indirect labor, buildings, and interest. Today there is more added value in building the picture tube than in assembling the whole CTV. A corresponding shift can be seen in investment: in 1986, components amounted to 13% of the \$26 billion turnover, but 30% of all company investment went to the components area. In the future, components will take an even bigger slice of the investment pie.

Incidentally, one can readily see why opportunities for introducing advanced technology at the components stage tends to be greater than at other stages. As we said, flexible manufacturing equipment that is big enough and smart enough to handle major changes in assembly routines is not likely to be cheap and friendly enough. But equipment that allows makers of smaller machined or molded components to be truly flexible are much cheaper, much friendlier, and already up and running. Ramchandran Jaikumar writes acutely that FMS technology allows parts makers—the healthy ones—to produce virtually any component at very high quality and at a cost equal to what used to be expected only from mass production.⁴

And so where factories producing subassemblies are tending toward CAD/CAM and a high degree of flexible automation, the trend among component factories is from high-precision mechanics to ultra-high-precision mechanics, from micron technology to submicron technology, from plastic or metal parts to integrated plastic/metal parts. Tolerances in these factories have become very exacting. Costs in R&D are unprecedented.

Suppliers Get Bigger, Not Richer

Given the enormous R&D investment required to manufacture components competitively, it seems obvious that components makers would tend to get bigger and bigger—that is, fewer and fewer—and would have to enjoy relatively high profit margins. Jaikumar argues that because of the new FMS technology, size is no longer a barrier to entry. But there are other factors which put small components makers at a distinct disadvantage.

To understand these, it is useful to divide the components industry into two areas: microelectronics and mechanical parts. The microelectronics area presents a clear case for bigness. Philips' newest chip factory in Nijmegen, Holland cost more than \$250

4. Ramchandran Jaikumar, "Postindustrial Manufacturing," HBR November-December 1986, p. 69.

million. The turnover necessary to recover such an investment profitably is correspondingly high. And developing new components in this area may also mean developing new materials and processes. Product and process cannot be viewed separately; Philips and Siemens together spent about \$1 billion mastering submicron technology.

The traditional Swiss watch industry was not vertically integrated. It consisted of watchmakers that designed and assembled the components of a great many small independent suppliers. When the Japanese watch industry gained a large portion of the world watch market by supplying quartz watches, the Swiss were taken aback. The quartz technology was totally new to Swiss suppliers, and many of them could not and would not adopt it. Swatch, the symbol of the Swiss recovery, is the result of a concerted effort involving all steps of the production chain from components to final assembly.

But high-tech components are found in the mechanical area too, which is why German automaker Daimler-Benz took over AEG (a \$3.5 billion company). Daimler-Benz also absorbed Dornier (\$750 million) for its know-how in lightweight carbon fibers and synthetic alloys, and MTU (\$1 billion) for its research and manufacturing capacity in ceramics. Large components suppliers, having wider technology bases, are in a better position to introduce new technology in any part of their businesses than are small suppliers.

And so with respect to size, the picture is as one would expect. Components manufacturers—the ones that have survived—have grown enormously over the last ten years, a trend that is clear whether one thinks of electronics components makers such as Emerson Electric, or comparatively small automotive components makers such as Simpson Industries. With respect to the growth of margins, however, the picture is surprisingly bleak. Profits are on the whole much higher for the makers and sellers of end products than for the makers and sellers of components. Big profits come from selling computers or automobiles, not from selling chips or shafts.

The reasons for this pattern are all too clear. Margins on general-purpose components—switches, wires, resistors, bolts—are lower than on customized components. And for many of these low-tech components, high-tech replacements with improved price/performance ratios often appear—all of which lead to dumping and the further shrinking of margins. True, the makers of standard components profit from large-scale production. But most of the benefits of scale are mitigated by brutal competition.

As for the costs of customized components, *their* development can be amortized only over a long time—at least three years in the auto industry. Yet the success of the end product into which customized components are designed is almost entirely out of the components makers' hands. Philips or Ford will introduce a range of products over the next five years; consumers will not accept them all. But components makers will have to bid to make the things that go into them all and, in many cases, produce prototypes along with their bids. These producers cannot expect to recover their costs for all the components they design—another reason, by the way, why the versatility that comes with bigness is an advantage.

None of this is to suggest that major manufacturing designers aim to build end products mainly from customized components. In fact, the opposite is true. Our best design strategy is to build as much as possible from standard parts but to develop a proprietary advantage in certain critical components—chips, decks, printed circuits, and so forth. Of course this strategy only adds to the components makers' difficulties. It tends to eliminate customization, hence opportunities to make high-margin items.

To be blunt, the typical big end-product manufacturer contributes a disproportionately small share of the value-added, while the typical components manufacturer reaps a disproportionately small share of the profit. Heads, the major manufacturer wins; tails, the components maker loses. All of which, obviously, brings us back to the subject of vertical integration.

Since most of the technology content of end products is in components, where earnings are shallow, major producers of technologically sophisticated goods will have to compete more aggressively for world leadership in component development and production—something the Japanese companies have been doing all along. Look at the 1986 ranking of the top integrated-circuit manufacturers by sales:

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| 1. NEC | 6. Philips |
| 2. Hitachi | 7. Fujitsu |
| 3. Toshiba | 8. Matsushita |
| 4. Motorola | 9. Mitsubishi |
| 5. Texas Instruments | 10. Intel |

The producers of end products that need microprocessors are slowly taking over this business; the list does not even include companies such as IBM (the world's largest producer of chips) and Hewlett-Packard, both of which make chips solely for their own use.

True enough, big manufacturers may want to take over certain components operations in any event, if

only to make it easier to coordinate design functions. Our point is that, regardless of design considerations, the financial pressures will ultimately force them to take over more components makers. Large, multi-national electronics companies like Philips are especially driven in this direction. Only within the integrated company will there be an assured flow of advanced components to end product manufacturers and a flow of capital back to components manufacturers. Only through vertical integration is the circle firmly closed.

Manufacturers that do not invest in vertical integration may, for a while, enjoy some cash advantages. Eventually, however, they will drive components producers out of business or, more likely, find themselves buying components from their own competitors. Philips took over Signetics in the 1970s to avoid such competition. Recently, Philips built its own factory for producing liquid crystal display (LCD) screens.

So the question is one of business goals. If you intend to maximize returns on investments, you may well decide to sell off suppliers. If, however, you strive for world market leadership, you will strive for vertical integration.

Will Competitors Be Your Suppliers?


In fairness to Hayes and Abernathy, conditions in electronics industries are somewhat different from conditions in, say, the auto industry. Auto suppliers may be so much a part of the family that major car companies will unilaterally guarantee the flow of capital back to high-quality suppliers either to keep them solvent or to underwrite promising research ventures. The makers of machine-vision quality control equipment springs to mind.

And yet automobile suppliers in Michigan, as everywhere else, are hardly thriving. The refrain one

hears again and again is that stockholders are losing patience with razor-thin margins. If suppliers could get together and build their own car, it would be another matter. But that, for components makers, is always another matter.

Viewed in this light, the growing strength of Far Eastern companies (especially Japanese) in the components industry constitutes a definite threat for Western high-volume manufacturers. In some areas, Far Eastern companies already hold an almost monopolistic position. Even in the important area of semiconductors, a traditional U.S. stronghold, we have seen the Japanese making major inroads.

The unabating pressure on prices will force an unabating search for components with better price performance ratios. Future developments in the television industry, for example, will take place in integrated circuits, surface mount devices, and picture tubes. A producer of television sets not sufficiently involved in the research in these areas will be in a very weak competitive position. (Philips is researching new generations of high-definition CRT tubes, wide-screen tubes, new processing chips, projection TVs, and LCDs.) Many improvements in the car industry will come out of electronics and new materials like ceramics. But will Western industries on the whole become dependent on integrated Japanese companies for critical components?

All in all, the tendency of many Western companies toward less vertical integration seems increasingly unrealistic. Flexibility downstream and innovation upstream are critical to manufacturing renewal. And this means that big companies will have to integrate their activities along the business chain and carefully plan to transfer capital from one link to another. Undoubtedly, manufacturers face a new world. The solid corporation of the future will, for new reasons, resemble the solid corporations of the past. 

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