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The Potential For Technology to Improve Productivity in Manufacturing

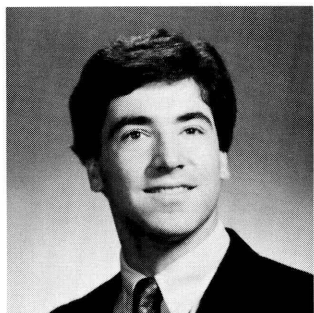
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THE POTENTIAL FOR TECHNOLOGY TO IMPROVE PRODUCTIVITY IN MANUFACTURING

William G. Pertusi

I. INTRODUCTION

It is generally acknowledged that a serious productivity problem has developed in the U.S. economy over the past several years. The rate of productivity growth in the private sector peaked during the mid-1960s. So too did R & D expenditures in both the government and the business sectors of our economy. At the same time expenditures for R & D were increasing in both Europe and Japan. Not so generally agreed upon is the cause of the problem. Some have pointed the finger of blame at excessive regulation, greedy labor unions, avaricious OPEC nations, or the Japanese. Branson (1982) attributes the productivity slowdown of the 1970s (which he views as a worldwide phenomenon) primarily to the rise in energy prices. However, it is becoming increasingly evident, as Hayes and Abernathy claim, that we have been "managing our way to economic decline." (1980, p. 67) Once we conclude that it is our own management doctrine that has caused our problems, we can begin to propose potentially sound solutions. Many solutions have of course already been suggested, and one that we hear most frequently is the notion that we can boost productivity growth through the increased application of technology.

The purpose of this article is to discuss the potential of technology for solving our productivity problems. We will first discuss the productivity problem in more detail and then proceed to point out how and why such technologies as Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Robotics have the potential to improve our manufacturing productivity. The limitations of CAD/CAM and Robotics will also be delineated, so we may better evaluate their costs and benefits for a firm. Finally, we will list the reasons why industry is likely to be slow in its adoption of these new productivity-enhancing technologies.

II. THE PRODUCTIVITY PROBLEM

In their 1980 *Harvard Business Review* article, Hayes and Abernathy expressed one primary criticism of American management practice—its excessive concern for short-run profit and the consequent neglect of the shop floor and the assembly line. (For further information on this issue, see Shauna Cohen's article in this *Review*.) Hayes and Abernathy partially attribute this American management philosophy to the significant shift which has occurred in the road to the top of the American corporation. Two decades ago in the course of their training, most executives were exposed to methods of production, to suppliers, and to customers. Today, however, new company presidents are likely to have had either legal or financial backgrounds. As a result, these top managers are directing more of their concerns to legal and financial matters than they are to manufacturing concerns. As Robert A. Frosch, Vice President in charge of General Motors research laboratories, states, "As a nation, we [have fallen] into the hands of the fast-buck artists. There [has been] a tendency to worry about the business side rather than the product or the technology side" (Holusha, 1982, p. 76). C. Jackson Grayson, President of the American Productivity Center concurs when he states, "American management has for twenty years coasted off the great R & D gains made during World War II, and has constantly rewarded executives from the marketing, financial and legal sides of the business while it has ignored the production men. Today courses in the production area are almost nonexistent" (Hayes and Abernathy, 1980, p. 74). Hayes and Abernathy even go so far as to say that we have actually developed a societal psychology in which we exalt financial analysis, rather than line operations. They point out that an over-emphasis on discounted cash flow methods, particularly in an inflationary environment, can be one product of this psychology which contributes to management's excessive concern for the short-run. One can easily understand how Hayes and Abernathy arrived at this conclusion by considering the present value concept and the time value of money in the light of our current inflation. A dollar spent today is more valuable (or costly) than the dollar spent a year from now because one year of interest on the dollar is sacrificed. By making investment decisions in a discounted cash flow environment, therefore, managers are less inclined to make capital outlays, especially during inflationary times. Moreover, with the high interest rates our economy has been facing, we have created a rather bleak investment picture—an impediment to capital formation for new technologies.

III. TECHNOLOGY'S ROLE

Despite this impediment to capital investment, it is essential that we still look to new technology in striving to improve productivity in manufacturing. As Drexel Burnham Lambert (1981) contends:

Economic growth in the 1980s will not be possible by employing more labor. A forthcoming decline in the working population means that increased production will require the use of more capital and the application of improved technologies. This should dramatically improve the levels of productivity in many sectors of the U.S. economy. Users of advanced equipment will benefit as productivity gains offset cost pressures. . . . The best opportunity to increase productivity in the manufacturing sector, we believe, is in the application of new technologies.

What do we mean when we refer to the "new" technologies? Primarily, we are referring to the computer and microprocessor related developments which have resulted from the integrated circuit and which could cause what some have termed the "Second Industrial Revolution." With the advent of the integrated circuit, electric and electronic circuits which used to occupy cubic feet of space are now microscopic. The microprocessor, an electronic integrated circuit half the area of a human fingernail, is actually a computer on a chip. (Integrated circuits are built on single layers of silicon which are sawed into die or "chips.") This marvelous microprocessor contains on the order of one million electronic components.

Contrast the microprocessor to the early digital computers which, with ten times fewer components, took up entire buildings, required hundreds of times more power, were thousands of times more expensive, and performed several hundred thousand fewer calculations per second. Toong and Gupta (1982) draw an interesting analogy to the aircraft industry to illustrate the tremendous increase in speed and decrease in power consumption and costs which the computer has enjoyed: "If the aircraft industry had evolved as spectacularly as the computer industry over the past 25 years, a Boeing 767 would cost \$500 today, and it would circle the globe in 20 minutes on five gallons of fuel." In addition to being a low cost, low power, exceedingly small electronic circuit, the microprocessor has memory capacity and even performs feats of logic. Thus it has the ability to make decisions for the machine.

The applications of microelectronic technology are seemingly endless and include numerical control machine tools, industrial robots, automated design systems, and automated materials handling systems. These productivity improving technologies will be discussed below under the general headings of Computer Aided Design, Computer Aided Manufacturing, and Robotics.

IV. COMPUTER AIDED DESIGN

CAD, or Computer Aided Design, permits design engineering, drafting, analytical testing, and process planning with the aid of a computer. In CAD, an engineer works at a CRT (Cathode Ray Tube, found in any television) terminal and enters a part's geometry via keyboard, electronic stylus, menu selection, or even via voice

in more advanced systems. Once a part's description is placed in the computer's data base, its image may be rotated, shifted, lengthened, magnified, cross-sectioned, or altered in any other way which the system software allows. A great advantage of CAD is that the information on the part can be stored in permanent memory allowing for retrieval and analysis at a later time. Automated drafting machines are used as output devices, producing accurate engineering drawings in minutes instead of days.

According to Gunn (1981), productivity increases (output per man hour) resulting from adoption of CAD systems vary from 300% to 600% with some cases reported as high as 1000%. In the process of part modification, which is quick and easy with CAD, a completely new, accurate drawing is produced in minutes which implies productivity improvements in the design process as great as 10,000%. A CAD system today, complete with such peripheral equipment as a digitizer, flat bed plotter, and CRT, sells in the \$400,000 to \$500,000 price range. CAD suppliers with the greatest market share currently are Computervision, Applicon, Calma (now owned by G.E.), and most recently IBM. A decade ago, perhaps only 200 systems were in place in this country. This number rose to 12,000 by 1979, more than doubled again by 1982, and is expected to continue to grow at a rapid rate. The highly productive CAD system provides cost reduction and market competitiveness for any manufacturer of mechanical or electrical equipment.

V. COMPUTER AIDED MANUFACTURING

CAM, or Computer Aided Manufacturing, encompasses several technologies including numerically controlled machine tools, programmable controllers, automatic storage and retrieval systems, flexible manufacturing systems, computer-aided inspection, and robotics. Numerical control (NC) machine tools have information stored in a computer's memory which then dictates the tool position for the desired work. (This information may, in fact, come from a CAD system.) Both point-to-point control and continuous path machining types are available, the latter being the more complex for obvious reasons. The major benefits of NC machining include reduced setup time, better part quality, less scrap and rework, reduced need for operator attention, and lower operator skill requirements. (Skilled machinists are generally in short supply.) Human error is thus essentially eliminated from the machining process; consequently, according to Gunn (1981, p. 162), productivity gains of at least 300% are the rule.

Programmable controllers (PC's) are basically microprocessors which can control a sequence of factory operations. A series of PC's can be linked to a master computer which can perform programming tasks. Automatic storage and retrieval systems allow for the retrieval and delivery of specific stock items with all locations recorded in computer memory. Computer aided inspection of parts is the

final link in a flexible manufacturing system, where a master computer can control a manufacturing process from start to finish. The integration of CAD with CAM improves productivity even further by drawing upon the same data base for design, choice of tools, choice of tooling paths, billing of materials required, choice of manufacturing process, inspection of the part, and even the routing of the product in the warehouse.

VI. ROBOTICS

One aspect of CAM—robotics—has recently grown to be a vast field in its own right. Industrial robots do not look at all like the robot in the TV series, “Lost in Space.” Rather, today’s industrial robots are computer controlled machines that automatically perform a sequence of operations. The microprocessor is once again the key to the technology, and a CAD system may be used to design not only the part itself but even the robot’s movements. Robots may be used to eliminate hazardous jobs, to reduce the cost of manufacturing, to improve product quality, and to ensure that better use is made of the firm’s other assets (such as people).

A robot consists basically of a mechanical arm, a power supply, and a controller. The controller is programmed to dictate all motion of the arm. Manipulators are placed on the end of the arm and are custom designed for the specific application. These applications include die casting, materials handling, welding, painting, and polishing. According to Professor Roger Nagel, Director of the Robotics Institute at Lehigh University, the automobile manufacturers are currently the only sizeable users of robots in this country, whereas in Japan robots are used in a wide variety of manufacturing applications. Currently, the big suppliers include Versatran, Unimate, and Cincinnati Milacron; and such established American firms as Westinghouse, Bendix, IBM, and GE are rapidly becoming involved in robotics production. A most notable recent addition to the list of American robot manufacturers is General Motors, which recently formed the GMFanuc Corporation (in cooperation with a Japanese firm) in order to produce industrial robots.

The 1981 sales volume of the robotics industry was \$125 million, according to Nagel, who predicts a \$500 million level by 1985. GMFanuc’s president, Eric Mittelstadt, projects sales of one to five billion dollars per year by 1990. Robots of greater versatility and technical ability will increasingly perform tasks in factory environments in which the supply of people qualified and willing to work is decreasing. Examples of such tasks include painting (which often produces noxious fumes), machining (which requires skills which are becoming increasingly rare), and heavy forging operations (which are performed under dangerous conditions).

VII. RESISTANCE TO ADOPTION

There is currently a vast array of technologies available to us, and many firms such as GE, GM, Caterpillar, IBM, and Black and Decker are applying them to improve productivity. Moreover, many observers still feel that these technologies are not being implemented to the desired extent. To better understand why automated design and manufacturing systems exist in so few American plants while the Japanese are well on their way to the "unmanned factory,"¹ we must consider the problems which an American manager typically faces in deciding whether to purchase such a system. According to Gold (1982), a top manager weighing a proposal to purchase such a system must consider:

- The absence in many companies of senior engineering and production officials who are knowledgeable enough about the potential of CAM to offer strong support for it.
- The need over a period of years for heavy capital investments which are not likely to show the immediate returns required by high hurdle rates.
- The failure of subordinates to consider seriously enough the threats to future competitiveness of continuing delays in adopting CAM technology.
- Vague fears about labor resistance to such adoption.
- The losses that result from subordinates' preferences for squeezing as much as possible out of existing plant and equipment, which may be inefficient, instead of assuming the heavy burden of new, high-priced, and undepreciated facilities.

Likewise, production managers and engineers considering the implementation of such systems must concern themselves with:

- The risks and personal insecurity involved in evaluating and applying unfamiliar technology, especially when real expertise lies with younger personnel.
- The financial penalties that usually follow the introduction of new equipment.
- Reductions in the autonomy of units as tighter integration of operational stages becomes essential and as high-level staff try to improve performance on a plant-wide basis.

Despite the obstacles, Gold stresses that "both levels of managers must take seriously the probable consequences of *not* adopting CAM technology: decreasing market share, cost competitiveness, and profitability and increasing unemployment."

¹The Fanuc Company uses robots to make their robots and, in fact, turns the lights off during the third shift since no workers are present.

VIII. CONCLUSION

The decision to adopt new technology is indeed a difficult one for any manager. However, American managers today must bear in mind several important points as they face these decisions. The adoption of a CAD/CAM technology is very different from the purchase of a single piece of equipment. CAD/CAM represents an integrated system whose capabilities will grow over time as operators and managers familiarize themselves with the system and its potential. In a carefully managed CAD/CAM environment, inventory levels are kept down and productivity is improved at each stage of design, manufacturing, and materials handling.

Even those who are aware of this potential may still fear the implications for labor in adopting a CAD/CAM system. There certainly will be an initial displacement of labor when such a technology is adopted, but as Gold points out, "More jobs have already been sacrificed because manufacturers have put off acquiring this cost-saving technology than will be sacrificed when they finally adopt it." Furthermore, large gains in employment in the longer run will be made possible by the increased output attributable to CAD/CAM adoption.

The Japanese and the Germans are already well-aware of these facts, and that awareness accounts in part for our difficulty in competing with them. If American manufacturing firms are to boost productivity and once again become competitive in world markets, they cannot afford to ignore the potential offered by the adoption of new technology.

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