THE PAYOFF FROM EXPERT SYSTEMS

What was once dismissed as an academic pipe dream is now saving some companies millions.

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Across the Board

For years managers have struggled to improve white-collar performance, with little success. Throughout the world, productivity gains in so-called nontouch work have been near zero.

Some companies are now reporting dramatic progress through use of "expert systems." Once considered a lab researcher's fantasy—a dream of recreating higher brain structures—these systems today have a wide variety of more down-to-earth applications, and a potentially large commercial market. In some manufacturing companies, as well as a number of firms in the service and public sectors, the payback from expert systems has been tremendous.

Jerry R. Junkins, chief executive of Texas Instruments Inc., explains why his company is looking beyond quality production: "Not too long ago, the ability to manufacture defect-free products consistently and at a low cost was viewed as the pinnacle of quality achievement. Today it is a minimum requirement for staying in business." To stay competitive, TI is building expert systems to improve its white-collar productivity. One of TI's many expert systems is a capital-proposal package that guides managers through the bureaucratic forms for requisitioning goods, making the process 20 times faster. TI expects the system to reduce cost overruns and preparation expenses by an average of $2 million a year.

Other companies report similar results. American Express Company estimates that expert systems increase the efficiency of its credit authorizers by between 45 percent to 67 percent. E.I. du Pont de Nemours & Company estimates a return on investment in expert systems through 1987 of 1,500 percent and an aggregate savings of $10 million. Digital Equipment Corporation believes it is saving $70 million a year from the 10 major expert systems it uses. One of those systems now makes it possible for sales people who are not systems engineers to design computer networks for DEC customers.

For three decades, artificial-intelligence scientists have struggled to build a computer system that would mimic human thought patterns and improve human productivity. Expert systems are the first commercial fruits of their labors. The systems are created by programming the knowledge of human experts and the logical steps those experts follow to solve a problem using a series of if-then rules. For example, "If payment of American Express card is six months past due, then deny credit." The if-then rules enable expert systems to reason and infer, rather than merely crunch numbers or store data. The systems can tell users not only what is the best solution to a problem but why it's the best. They give less-experienced employees an alternative to wading through a 5,000-page technical manual for the answer to an air-conditioning problem or tracking down the one retired engineer who knows how to prevent slag drift in a phosphorous furnace.

A recent book, The Rise of the Expert Company (Times Books), celebrates the advances that expert systems have made in the 1980s. Written by Edward Feigenbaum of Stanford University, widely regarded as the father of expert systems, along with Pamela McCorduck and H. Penny Nii, the book highlights the work of dozens of junior engineers, middle managers, and CEOs and shows how they have championed the use of expert systems in their companies.
For instance, Ken Lindsay and Bob Joy are two young engineers working for Northrop Corporation who attended a computer conference where they were given a "toy" expert-system program that plays a kind of computerized "Twenty Questions"—guessing which zoo animal one is thinking of by asking such questions as, "Is it a mammal? Yes. Is it carnivorous? Yes. Is it striped or spotted? Spotted. Is it a leopard?" Lindsay and Joy decided, on their own, to adapt it into a program that plans the manufacturing of fighter-plane parts. Using an Apple personal computer, they secretly labored after work and on weekends to rewrite the toy program. (Their program consists of rules such as, "If the edges of a sheet metal part are irregular, and the minimum internal radius is greater than .156 inch, and the length is between 90 and 140 inches, and the width is between 2 and 45 inches, THEN rout this part using the Marwin router.") Once they converted the program to plan airplane parts, they put the Apple on a dolly and dragged it around Northrop to drum up corporate support. Their tale, like all of the stories presented in the book, has a happy ending. A vice president of research took up their cause and today Northrop reports that Lindsay and Joy's system reduces the time spent planning a manufacturing process from several days to four and a quarter hours and allows a trainee with only a few weeks' practice to behave like a master planner with a decade of experience.

As with most technical advancements, the success of expert systems rests on gaining the users' support. Predictably, the Feigenbaum book reveals that engineers and scientists have embraced expert systems, while salesmen and accountants have required a bit of arm twisting. Ironically, the authors of the book found that the stiffest resistance to expert systems came from MIS departments. "In company after company we were told of the struggles between the expert-systems champions... and the powerful corporate service bureaucracy known as Management Information Systems, the dreaded MIS." MIS, it seems, suffers from a worldwide case of the not-invented-here syndrome. MIS has the ability to undermine an expert system by failing to provide computers that have fast enough processing speeds. Studies show that if the time between a user asking a question and the computer responding to it is too long, the user will become impatient and won't take advantage of the system—even if it improves his performance.

Feigenbaum and his co-authors also provide a bit of commentary on how a company can develop its own systems. Disappointingly, the insights are mainly on ways to weasel money out of top management and exploit the old-boy network to garner people's support. Problems are breezed over throughout most of the book. In a section on DEC, for instance, the authors conclude that its "history with expert systems isn't a tale of nonstop success. Some areas, such as planning and scheduling, haven't noticeably yielded to expert-system treatment, though prototypes were designed and built." However, it is never explained why there were difficulties; details are only provided for successes.

The literature on failures is generally scarce, but what is available provides useful guidelines for developing systems that will work. Institutional Investor noted last July
that the first failures in financial expert systems were caused by lack of support from upper management—including one for interest-rate swaps by what was then Lehman Brothers, a loan analyzer built by Mellon Bank, and an underwriter evaluator developed by St. Paul Companies. Later failures, the article claims, were caused by too much support from middle management and not enough guidance from above, leading to costly duplication of efforts and ugly turf battles.

Senior management must continue to be involved after the system has been developed and put into use. Some systems have faltered in the field because management hasn't insured sufficient maintenance. Maintenance simply means entering new information into the system, whether it be new regulations or a better way to solve a problem. A system that is not maintained will soon be outdated and fall into disuse. Maintenance, however, may not be cheap: DEC spends $2.5 million a year on updating its expert systems and employs 15 people to do the work.

We've all used automatic teller machines and other computer systems that answer our questions. So what is so special about expert systems? The key lies in their flexibility. Compared with structured programs created by languages such as Pascal and C, expert systems are relatively easy to adapt from one situation to another (remember the zoo-animal-turned-fighter-plane system) and are much easier to update. Because the technology is not as complex to use as many had expected, a lot of companies are turning to it to improve their performance. One analyst estimated in High Technology Business that half of the Fortune-500 companies are now investing in the development and maintenance of expert systems.

Some of the systems are quite simple and have been designed on PCs by experts with no programming experience using inexpensive commercial software packages called shells. A shell is somewhat analogous to a spreadsheet in that it prompts the user to “fill in” knowledge. The 1st-Class software shell, produced by First Class Expert Systems of Wayland, Massachusetts, sells for just $495—a far cry from the $100,000 systems marketed just a few years ago. In the past three years, the firm has sold 3,500 copies.

Du Pont is one company that has taken full advantage of low-cost, user-friendly shells. By the end of 1987 it had put 1,500 employees through its two-day expert-systems course. Students learn to use 1st-Class and Insight (another inexpensive commercial software package) as well as Du Pont's own shell, Tool Kit. Du Pont's grass-roots approach has met with much success. By mid-1988, it had more than 200 expert systems in routine use, with 600 under development or in field tests. A typical system requires one man-month of effort to build and yields $100,000 in savings per year, says Ed Mahler, director of Du Pont's artificial-intelligence program.

The popularity of low-budget systems has forced artificial-intelligence companies to change their marketing strategies. They have had to accept the idea that expert systems are simply an advanced form of software—and that most companies will only pay for their services if the systems can be used on the personal, mini, or mainframe machines that the companies already own. Many of the original artificial-intelligence companies are now millions of dollars in the red because they marketed systems that required esoteric programming languages and expensive, specialized computers, which couldn't “read” corporate data bases. Today the leaders in the field, such as First Class, are selling inexpensive, compatible software that novices can program in everyday English.

Yet some companies remain convinced that purchasing large, customized systems that require highly trained programmers is the way to go. Robert Flast, vice president of transaction services at American Express Travel-Related Services, argues in the Feigenbaum book that if expert systems are going to be useful to a firm, it's best to develop those of great impact and value first. To design its expert system, which sorts through as many as 13 data bases and makes recommendations to authorizers as to whether or not to grant customer credit, American Express contracted out to Inference Corporation of Los Angeles. After more than a year of development, American Express is ecstatic about the results and anticipates a return on investment of $27 million. Flast, according to the book, feels
that the greatest opportunity for expert systems lies in improving customer service while reducing losses from bad decisions on whether or not to grant credit—usually antagonistic goals, since giving more service usually costs more.

The debate between "cheap and dirty" shells and "dear and spotless" customized programming will linger. A few prescriptions, though, may be drawn. If the system is expected to make better judgments than the user and perhaps do some of his work, a customized program such as American Express's is most likely necessary. By contrast, if the system is designed to advise the user and let him make the ultimate decisions, a commercial shell is probably sufficient.

Most experts warn against tackling far-reaching projects that promise flashy results. A customized program not only costs 10 times as much as a shell, on average, and takes 10 times as long to develop but also can dampen employee enthusiasm for expert systems if it doesn't live up to expectations. Customized systems will have to offer extraordinary increases in productivity to justify their higher costs and greater risks.

It may also be foolish to develop too limited a system. A recent British book by Michael L. Barrett and Anabel C. Beerel, Expert Systems in Business, claims that while the Du Pont method of letting experts build their own systems has the advantages of low cost and quick development, it has the drawback of producing systems that are suitable only for the experts who designed them. "At Du Pont," according to Barrett and Beerel, "the great majority of the live systems are only used by one person." To get the most out of the technology, managers should promote the development of systems that will improve the performance of a number of people—perhaps by insuring that amateur developers are helped by experienced programmers.

Once a firm invests in a shell or customized program, it is likely that it will have to address workers' fears that their jobs will be replaced by these computers. In The Rise of the Expert Company, the authors credibly argue that most systems capture knowledge that will be lost as human experts retire or die. They also point out that it is often most efficient to automate the mundane part of an expert's job, leaving him time to concentrate on the remaining "difficult" problems. In the Feigenbaum book, Dr. Robert Fallat, who helped develop a diagnostic system for lung diseases, explains a view common among users: "If the computer can handle the routine 80 to 90 percent of the cases, that's okay. It frees me to work on the other 10 to 20 percent, which are the really interesting medical cases." Bruce Johnson, a partner at Arthur Andersen & Company, is also cited as believing that these fears are mostly unfounded: "Three-quarters of the Arthur Andersen expert systems have been new value, new products, and new services, as opposed to mere cost reduction. If cost savings is the only goal, it's too limiting. Manpower saved through expert systems isn't nearly as important as faster response, improved quality of service, and competitive differentiation."

Though many companies are investing in expert systems to help their employees perform better, not to replace them, workers remain skeptical. The Feigenbaum book quietly mentions that IBM's manufacturing system for making computer printers is a success because it has reduced the number of workers on the production line by 10 percent. And, in Expert Systems in Business, American Express's system for helping salesmen design computer systems is said to have permitted the team of experts who check the sales force's work to remain at a constant size of about 12 people. Without the expert system, the book says, it has been estimated that 100 experts would be required to cope with the current workload.

A company that reduces manpower by relying on expert systems may be hurt in the long run. Expert systems can impose uniformity on its users, stifling imagination and conceptualization. An overreliance on expert systems for making business decisions could produce a generation of managers who have little faith in their own intuition or expertise.

The future also holds the threat of liability suits. Who is liable if the expert system fails? Some expert systems may fail due to their design, while others may fail because they are improperly used. In either case, third parties—workers, consumers, community residents—may be harmed as a result. Possible
lawsuit targets include the user, the programmer, the supplier of the shell, and even the expert whose knowledge was captured. There have already been failures in expert systems used in medical diagnosis and radiation treatment (allegedly because of their design defects) that caused severe injuries and deaths. Systems used in air transport have also allegedly failed.

Regulation and legal precedents on expert systems are just beginning to emerge. This past September, the Food and Drug Administration announced that software “intended to be used without competent human intervention” is subject to FDA requirements. It also warned that it will keep tabs on medical uses of expert systems for possible future regulation. Courts, according to Christopher Gill in an article for *High Technology Law Journal*, must soon decide whether an expert system is a product or a service. “Classification as a product,” Gill writes, “means that the developer, manufacturer, and seller may all be subject to strict liability.” Strict liability means they may be liable without the need for the victim to prove the defendant’s wrongdoing. If expert systems are classified as a service, an injured plaintiff would most likely have to establish negligence.

A number of other issues must also be decided by the courts, including whether a human expert has a right to royalties for a system that contains his knowledge. One ongoing lawsuit involves a client who provided the expertise for a system as part of his job. He has since lost his job and is suing the company for royalties on the system he created. Another headache for companies involves the type of hold-harmless agreement they must provide if they choose to market their systems. These disclaimers, which deny responsibility if the software fails to work as promised, often carry little weight in the courtroom—one reason is that most buyers never sign the license-agreement cards. To protect themselves from lawsuits, companies may have to provide warnings about hazards posed by their products. An additional debate, yet to be settled by the courts, is the meaning of informed consent in doctor-patient relationships involving expert systems. Can a patient give a machine the right to make decisions about his treatment?

Meanwhile, companies are moving cautiously. According to an article in the October 1988 issue of *High Technology Business*, one company that was planning to sell a medical expert system “sank a couple of man-years [of development time] into it and, when they looked at the cost for liability insurance, they said ‘no way.’” Ironically, some law firms are using expert systems to decide when it is profitable for clients to file suit. A smart manager will reduce the risks of using expert systems by insuring there are adequate contracts with the expert whose knowledge is to be immortalized, devising systems that recommend action without acting on their own, and obtaining liability insurance.

Finally, expert systems pose a security problem. Are the standard methods for data protection sufficient for protecting a company’s proprietary expertise? Given the outbreak of computer viruses that have infected Pentagon, university, and corporate mainframes, it is clear that computer systems are vulnerable. When it comes to expert systems built on PCs, the odds of computer espionage skyrocket because a corporate spy can take a floppy disk and quickly copy information. Companies developing systems for financial or business-management purposes in the hopes of gaining a competitive edge are especially concerned about this. Unilever P.L.C., for example, was touted in 1984 as being the bellwether of British users. In 1987, however, every one of its expert systems was being kept completely confidential.

Expert systems are practical means of increasing white-collar productivity and improving customer service. But problems of scope and liability remain. Dorothy Leonard-Barton and John J. Sviokla, assistant professors at the Harvard Business School, wrote in a recent *Harvard Business Review* article that “realization of the potential of this evolving combination of human and machine knowledge hinges as much on management as on the technology itself.” They claim that the projects that succeed are usually driven by either the preeminent expert in a field or a business manager. “That person, being the best judge of the trade-offs that often must be made during development, should have the last word on the content and process of the actual expert system.”