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## Computers are kicking up a furor as they transform the way the financial world bets its money.

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**O**NLY 18 years ago, a sudden swamp of orders — upwards of 16 million shares a day — forced the nation's major stock exchanges to close every Wednesday, for weeks, to catch up on paperwork. Today, with computers ubiquitous on Wall Street, the New York Stock Exchange alone handles 10 times that trading volume with ease.

Now, after two decades of electronic evolution, Wall Street's computers are far more than mere pencil pushers. They have been turned to an array of unexpected uses that have fundamentally changed the world's investment patterns.

They have permitted the creation of new financial instruments, including stock index futures and options, now traded heavily every day in Chicago. They have brought volumes of information to investors,

often more data than even professional traders can absorb. And, through links to overseas exchanges, they have led to round-the-clock trading, and made it possible to swap funds instantly from equities to futures, and from exchange to exchange.

Even the worst computer phobes concede that, by now, the computer is a Wall Street fixture, as a tool — and as a counselor. People who hoped to see the likes of HAL, from the movie "2001," running Wall Street will be disappointed. But there is software on the drawing boards that may help computers not only spew forth data but reason out trading strategies.

The use of computers to detect, and sometimes inspire, all kinds of profitable trading opportunities is just the latest example of the way a technology brought in to solve one problem can dramatically change an entire industry. And as in other such cases — the way atomic energy affected electric utilities, or the way the laser has transformed military electronics — the price tag on the progress is only now becoming evident.

A growing number of financial experts — to say nothing of jittery small investors — accuse computers of having created a market that is virtually run by machines. And they point to days like Sept. 11, when the Dow Jones industrial average plunged more than 86 points, as proof that such computer-aided approaches as program trading, which involves instantly swapping long lists of stocks, futures and options to take advantage of temporary price dispari-

ties, set off wide and chaotic market swings.

Proponents of computer-assisted trading say that by allowing investors to act on market-moving news far more quickly and effectively, computers have engendered fairer, more efficient markets. "By and large the technology just speeds up what people have done before, causing the markets to react much more quickly," said William J. Brodsky, president of the Chicago Mercantile Exchange, the main trading place for stock index options and futures.

Others note that if the acceleration has created temporary market spasms, more technology may solve that problem, too. The price swings really are rooted in the differing expectations of traders looking at different data, they say, and thus will become far less frequent as financial exchanges across the world become more tightly linked.

And even the swings are not entirely negative: There were few complaints when program trading apparently triggered the 31 point rise in the market last Wednesday.

Still, there are rising concerns, including some from Federal regulators, that computers may be doing more than accelerating what comes naturally. By making possible instantaneous analyses of a crush of data about short-term market aberrations, a raft of new hardware and software has drawn institutional

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# Wall Street's Tomorrow Machine

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investors into trading patterns that have little to do with fundamental values of companies or prospects for the economy.

And that, in turn, has meant a frenzy of short-term trades that some experts, though hardly all, believe has created significantly more volatility. Along the way, individual investors, already bit players in markets dominated by institutions, are scared away once again: Most cannot devote the time or resources to take advantage of short-term market swings whose causes become ever more mysterious.

"Simply put, the public cannot compete with the professional traders at this stuff," said William Silber, a professor of finance at New York University's business school.

Even the traders may be overwhelmed, others say. "All of a sudden, the people doing the analysis are getting more data than they can reasonably assimilate," said Warren Pyles, the president of Marketvision, a three-year old company that sells programs that put data into easily digestible graphic form. "And they are being asked to make faster and faster and more costly decisions. It is a double whammy."

Imminent developments promise to add even more fuel to the fire. Already more than a few financial pro-

fessionals, and dozens of software houses, are working to apply artificial intelligence techniques — techniques that enable computers to replicate certain limited forms of human reasoning — to the trading process. The idea is to let the computers themselves make instant, accurate judgments about relative prices of stocks and other financial instruments, involving tradeoffs too complex for even veteran traders to tackle quickly.

Whether Wall Street will prove entirely capable of absorbing such technology, much less control its effect, is unclear. The computer's assault on the Street has occurred only gradually, with no grand design. And progress has been dictated, as in so many other industries, not as much by the availability of technology as by the ability of financial professionals to master it for their own purposes.

Already, they have sought help. The Street's newest professionals are the "rocket scientists" and "quants" — oftentimes former academics in the pure sciences of mathematics and physics — who search for new ways to apply the computer to all sorts of problems: creating mortgage-backed securities, minimizing transaction costs, timing the sale of huge volumes of stock to maximize profits.

More elusive are ways to quantify less predictable market factors. How, for example, would a program factor



in a war in the Middle East or rumors of a big Chapter 11 filing?

Still, computer researchers do seem to be making it feasible — if not desirable — to have computers that truly dominate the financial markets.

"The inevitable result," said Prof. James Beniger, a University of Southern California expert on computers and control systems, "is that people will begin to write programs that seek to anticipate the decisions that other computers will suggest. It's just market psychology, one step removed, and one more step away

from direct human control."

Such suggestions anger traders at the brokerages that make the broad use of computer technology, like Salomon Brothers. "There is no computer, no program on Wall Street or anywhere else that buys and sells," argues Louis I. Margolis, managing director of Salomon Brothers Inc., as he stood in the firm's chaotic trading room the other day. "Nothing is going to replace human judgment."

FEW of the computer-assisted trading techniques are new. But in the past, they were never widely practiced, largely because by the time the calculations were done, the market opportunity was long gone. No more. Program traders, usually armed with little more than an I.B.M. PC-AT, a Lotus spreadsheet — and, of course, a huge amount of money to trade with — now can translate theoretical profit opportunities into highly lucrative trades.

"What's different now is volume and speed," notes Mr. Brodsky. "The idea of buying the entire S&P 500 in two minutes, in the right proportions or something that simulates it, is something no one dreamed of before. And that, of course, can change the nature of the market."

A few individual traders switching funds between equities and stock index futures, or using any of the other program trading techniques, would barely move the market at all. But because profit margins on program trades are usually slim, the program traders must move millions of dollars at a time to make it worthwhile. Thus, the execution of many program trades at once, all seeking to exploit the same opportunity, can create such an impact that the market does not have a chance to self-correct. "Program trades can have a snowballing effect, and investors can be taken for a rough ride," said Jack A. Barbanel, director of futures trading at Gruntal & Co. Inc. in New York. Of course, Mr. Barbanel and others point out, technology by itself is neutral. It is widely available, and its continued wide use is inevitable. But it will always be the users, not the machines, that create the stabilizing or destabilizing effects.

"What fostered all this was the markets themselves, and the growth of derivative instruments: Futures, options, options on futures," notes Jay Light, a professor of finance at Harvard Business School. "That's what created the opportunity that people exploit with the technology."

Those instruments create innumerable opportunities for arbitrage, which involves trading on differentials in, say, the price of a Standard and Poor's 500 Index futures contract versus the price of underlying 500 stocks. Calculating those differentials

in their simplest form can be done on the back of an envelope, without benefit of a glowing screen and fancy software. But by linking computers directly to "real-time" information services, traders can have their own positions recalculated instantly — and can be alerted to any opportunity when it might make more sense, for example, to trade equity holdings for future holdings.

Simultaneously, there are programs that can work out the most expeditious way to "hedge" a portfolio, insuring it against sudden market declines. And there are programs that make it possible to figure out how to minimize transaction costs by selling a relatively small representative group of the S&P 500, or how to unwind a position in some stock without depressing the market.

Obviously, as the techniques get more complex, computers become indispensable. "Arbitrage is basically a mathematical game," said Professor Light, "and thus a game that computers are very good at."

IT was the need for speed, rather than for mathematical wizardry, that put computers on Wall Street in the first place.

By the mid-1960's, when the mainframe computer was first coming of age, it became clear that neither the stock exchanges nor the brokerage houses could keep up with the paper blizzard created by steadily growing trading volume. There were just too many records. There was the paper record of an order, which had to be placed in the hands of a trader on the

markets, for example, than in equities, but under some conditions it might be cheaper still to simply wait awhile, putting part of the portfolio in a risk-free instrument like a Treasury bill.

Perhaps lost to history, in the midst of all this technological flurry, is the rise of the phrase "program trading." Wall Street traders flinch at those words, fearful that they conjure up images of machine-run markets, the financial world's answer to a launch-on-warning nuclear policy.

Hard-liners like Mr. Margolis of Salomon even dislike the less intimidating wording of "computer-assisted trading." Says he: "There are chips in the dashboard of your car. Is that computer-assisted driving? Of course not."

The difference, other experts argue, is that the dashboard chips do not yet suggest the routes a driver could take to reach a specific destination. Some trading programs do, though not explicitly. Still, the final judgment is in the hands of the human trader. The computer could warn of an aberration between S&P 500 futures prices and the price of the underlying basket of stocks, yet an experienced arbitrager could realize that the opportunity to exploit that difference is so brief that it would be gone by the time a trade is made.

"There are a lot of human judgments to be made," said Mr. Barbanel of Gruntal & Co. "Technically, it would be possible to have the computer execute these trades for you, but you might not like the result."

A CONSENSUS is emerging that, as the importance of networks that link buyers and sellers increases, the importance of the exchange floors will diminish. "We are talking about an age where the stock market floor and the Chicago pits are a dinosaur. Trading off a screen creates a real, free-flowing marketplace" where everyone can participate, said Mr. Barbanel.

More debatable is the question of whether computer-assisted trading encourages volatility. Many argue that it does, particularly the buy and sell programs used in stock index arbitrage. The baskets of stocks are usually very large, involving several hundred different securities worth millions of dollars.

But it does not follow that the markets are necessarily more volatile, at least in the long run. In fact, sometimes a program trade narrows the gap between two markets. On a percentage basis, according to one Salomon Brothers study published by Lazlo Birinyi Jr. and H. Nicholas Hanson in July, the markets today are not as volatile as they were in the 1920's or the 1930's. And they point out that while futures and options are claimed to spur volatility, the British market has recently been far more volatile than the New York Stock Exchange, although futures and options trading in Britain is minimal.

Of course volatility, or even the perception of it, is what scares small investors. And that is the second complaint about how the computer has changed investing: that they have given professional traders another, major advantage over the little guy.

That argument seems difficult to support, however. For all the activity that computers spur, it is not clear that they help predict the broad trends of the market. "Because the programs look at technical features of the market, they don't tell you a whole lot about fundamental issues that move stocks," said Prof. Light of Harvard. "The only advantage might come if you know when a program trade will kick in. That could be valuable information because an investor could try to get in ahead of it."

Moreover, individual investors seem little interested in harnessing the power of the computer themselves. Lotus Development Corporation has tried for a year to market "Signal," which links a personal computer, running a 1-2-3 spreadsheet, directly into real-time market data. So far, sales have been disappointing. "The question isn't computer power," said one Lotus official. "The question is whether people want to spend their lives in front of the screen watching the market. It looks like they have better things to do."

But the most worrisome aspect of the ways computers are used now in financial markets, particularly in the case of program trading, may be how they have polarized the marketplace. One group of investors still focuses primarily on market fundamentals: A company's prospects, the strength of its management, the state of the economy. Another, growing sector focuses primarily on mathematical, short-term price discrepancies, the kinds of factors that computers, by their nature, can easily seize on.

Just ask the company whose computers won Wall Street: I.B.M. Its executives bemoan the fact that I.B.M.'s stock gets buffeted most heavily whenever program trading starts, because the company is such a major presence in every stock index and a favorite of institutional holders.

"Program trading is a concern to us because it has introduced into the marketplace an element of volatility which is unrelated to economic conditions or a company's financial performance," the company said in a statement recently. "We are concerned that individual investors will lose confidence in the market because stock prices are being driven by an increasing number of factors that have little to do with business fundamentals."

A senior I.B.M. executive conceded recently that there was some irony in the world's largest computer company complaining about program trading. But, he joked, "Computers don't kill stock markets. People do."

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stock exchange floor. There was the paper record of the sale, including the price. And later there was the paper record of the stock certificate — a particularly difficult problem because of individual investors, whose small orders generated only a fraction of the market volume but a huge portion of the paperwork.

On Dec. 20, 1966, the New York Stock Exchange embraced automated record-keeping for the first time. Brokerage houses followed along — some grudgingly, others with enthusiasm — and by the mid-1970's their computers were linked directly to their branch offices at one end, and to the exchanges at the other. Another system put buy and sell orders directly in front of the specialist.

If the first generation of financial computer systems kept records, the second spurred business. Salomon Brothers, Merrill Lynch and Goldman Sachs, among others, began compiling lists of which pension funds and companies owned or usually sought specific securities.

"Everyone woke up to the fact that the computer could help them find the other side of any big trade," said Professor Silber of NYU. "The major commodity that investment bankers have is this information." In turn, that spawned more block trading, which in its early days was accused of causing many of the same evils — market volatility, squeezing out small investors — now laid to program trading.

All the while, analysts, strategists and traders were beginning to think about the third, and equally obvious, use of computing power: Analytics, the use of computers for evaluating new trading opportunities. Clearly, greater processing power could aid stock analysts in predicting the fortunes of individual companies. But computers could also be programmed to evaluate short-term phenomena where the investing choices were not obvious: Whether to put money into securities rather than Treasury bills, when to sell a large market position in a particular stock, how to reduce risk in a specific portfolio.

But analytics didn't really flourish on Wall Street until the confluence of three different forces: Faster market information, cheaper computers, and the arrival of software that non-programmers could use.

The faster market information came in the form of real-time data systems such as Telerate and Quotron, which made it possible to sit at one desk, anywhere in the world, and scan screens full of up-to-the-minute information on stock prices here and abroad, on Treasury bills, and on futures and options. Now, in a transition still underway, comes the next step: To feed that data directly into desktop computers that actually massage the information rather than just display it.

Meanwhile, the raft of programs — starting with Lotus 1-2-3 and working up to far more specialized software for particular trading purposes — allows traders to ask the natural question: "What if?" With the press of a button, they can compare the advantages of innumerable investments. Each choice, of course, carries a different transaction cost: It is generally cheaper to trade in the futures